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## An Improved Electric Steel Furnace

By Dr. Alfred Gradenwitz.

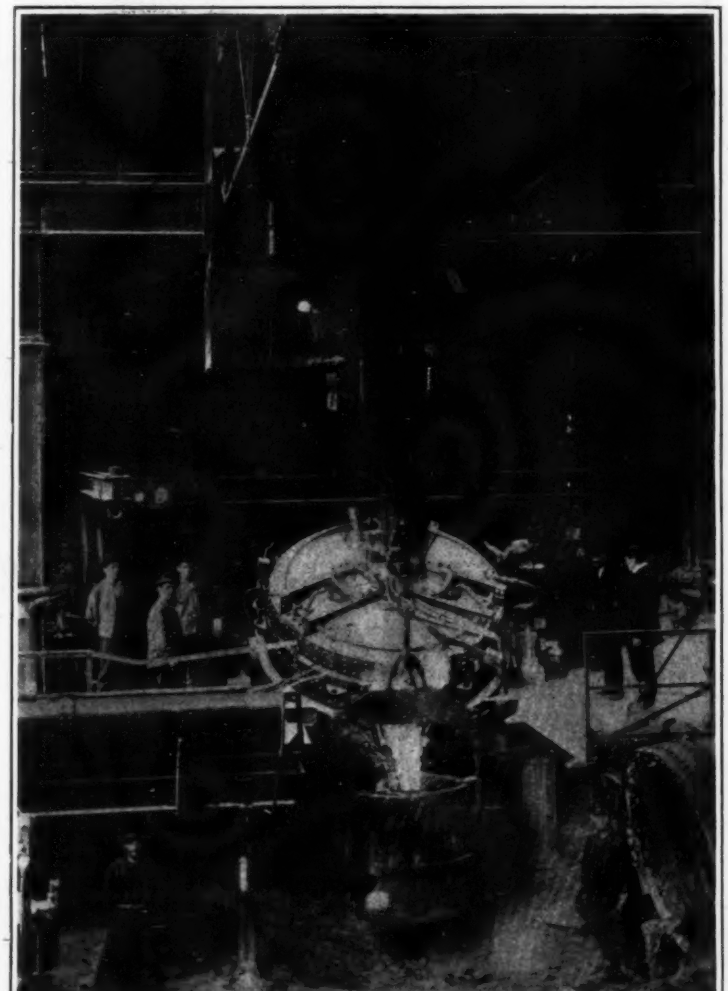
In designing the electrical steel furnace described below, Dr. H. Nathusius has endeavored to combine the individual advantages of the Héroult and Girod furnaces, while avoiding the drawbacks of either.

In this furnace, which is of the combined arc and heating currents obviously is as economical as can be desired.

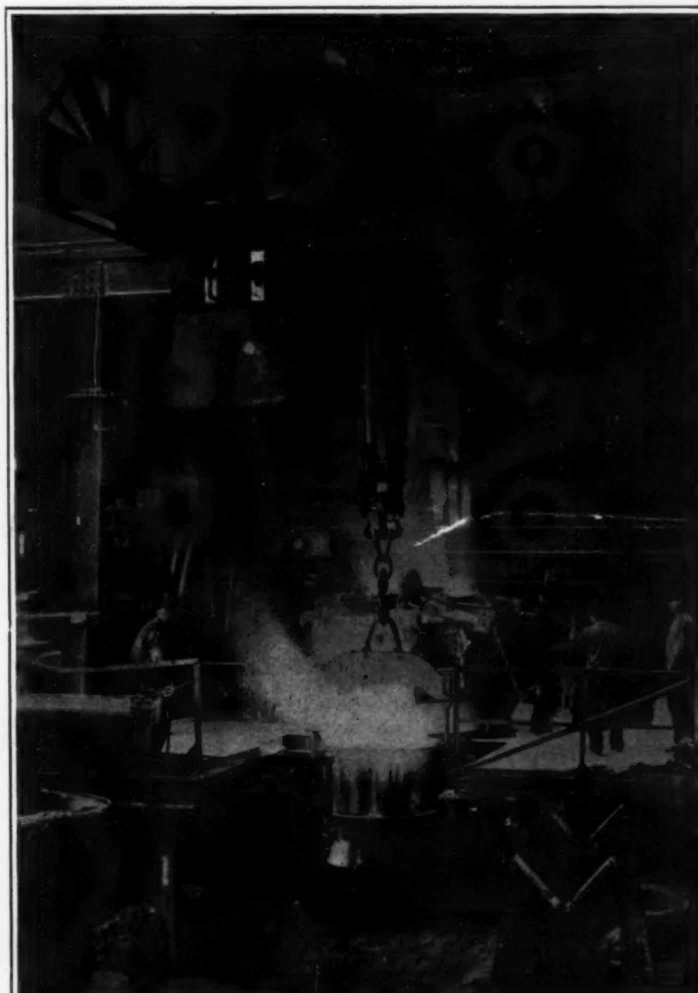
Again, the fact that the current is distributed to the whole cross-section of the bath, that is, both to its surface and bottom, is bound to result in another beneficial effect, by forming rotary fields which, similarly as in the case of a three-phase current motor, will set the surrounding iron parts rotating.

upon the bottom electrode, any shocks produced by short-circuits in the electric arc are compensated, as it were, by an electric buffer, thus dispensing with any furnace regulation in the case of normal operation.

A further advantage from the electrical point of view is that the current flowing from one bottom electrode to the other is readily transformed to any intensity by the aid of a special generator with



POURING OUT THE CHARGE



THE OPERATION OF TAPPING

AN IMPROVED ELECTRIC STEEL FURNACE.

resistance type, there are three surface carbon-electrodes penetrating vertically into the hearth compartment, at the angles of an equilateral triangle. These electrodes are connected up to the outside terminals of a three-phase current generator or transformer, whereas three steel, electrodes enchased in the bottom (which are likewise arranged at the angles of an equilateral triangle) are joined to the inside terminals of the same three-phase current generator or transformer. These inside terminals are obtained by dissolving the neutral point of the machine and transferring it into the charge. As accordingly the surface electrodes as well as the bottom electrodes are of mutually alternating polarities, the current passes from one surface electrode to another, from one bottom electrode to another, and from each surface electrode to one of the bottom electrodes. In fact, there is inside of the charge a perfect compensation of currents, in opposition to the surface currents of the Héroult and the cross currents of the Girod furnace. This heating process, according to which the whole of the charge is traversed and encircled by

It further will be readily understood that in the Nathusius furnace, with its six heating focuses located at the issue of the current from the various electrodes, the bath can be heated and throughout its mass much more rapidly than in furnaces only comprising two heating centers. As, furthermore, the surface electrodes are placed as close to one another as feasible, the electric arcs will repel each other by virtue of the electro-dynamic forces exerted on one another by currents of equal direction.

Apart from this advantageous heating effect, the electrical arrangement of the Nathusius furnace is exceedingly favorable. As three-phase currents are used in practically all large metallurgical works, the use of this type of current is doubtless advantageous, while the problem of including the charge in the circuit is solved most ingeniously by locating the neutral point in the bath itself, thus accurately prescribing the path of the current, independently of any resistances. As the circuit comprises not only the electric arc, which is bound to vary continually, but the slag layer, the steel bath and the mass rammed

adjustable neutral conductor or else by means of a booster transformer. As this current only flows between the bottom electrodes, viz., through relatively small resistances, its intensity can be increased without any necessity of using machinery of excessive dimensions, which obviously renders it possible to obtain very strong effects.

While during the first stage of operation (the refining stage) an effective heating of the slag (the only refining agent) by intense arcs is of much importance, it should not be overlooked that during the ensuing deoxidizing stage the slag acts only as a protective cover, and accordingly requires no strong heating. During this second stage the whole of the bath should therefore be heated as effectually as possible, which in the Nathusius furnace is done by using a booster transformer, and thus deriving from the electric arc a considerable amount of energy concentrated in the bath or the bottom.

After once preparing the charge, it is often desirable to allow the bath to rest for some time, during which stage the amount of heat to be added only

corresponds to the heat lost by radiation and conduction. This, in the Nathusius furnace, is effected most advantageously by cutting out entirely the surface electrodes, allowing current only to flow between the bottom electrodes, and thus doing away with arc heating.

Being of a round shape, the furnace is pivoted in the same way as a converter upon two uprights, the tilting device being operated electrically or hydraulically. The bottom electrodes, which are made of cast steel, are fitted into the bottom from underneath; they do not penetrate into the steel bath, and are covered by a layer consisting of the same material as the furnace-bottom. The whole of the furnace, except the lid, consists of a rammed dolomite mass, and is very durable, as is also the lid, which is made of argillaceous materials, quartz slate and the like.

A furnace constructed on the above lines by the Bergmann Elektrizitäts-Werke, Ltd., of Berlin, which has been in operation for more than a year at the Friedenshütte Steel Works, was recently tested by Dr. B. Neumann of Darmstadt.* This furnace derives its electrical energy from a three-phase current transformer, the high-tension end of which, wound for 6,000 volts, is connected up to the circuit of the power house supplying the steel works. The low-tension winding is so designed that both ends of each of the three coils issue out of the transformer, each of the three windings being connected at one end with a surface electrode, and at the other with a corresponding bottom electrode. The rails, which are made of flat copper, are designed for a permanent current intensity of 2,500 amperes. The transformer is able permanently to yield 550 kilowatts, and at the low-tension end gives an inter-linked tension of 110 volts. The phase tension thus is 63 volts, which, disregarding tension losses in the conductors, is the tension between the surface and bottom electrodes. Into the conductors leading to the surface electrodes is inserted a switch which short-circuits these three conductors, and thus allows the bottom electrodes to be used alone for current supply.

The furnace transformer is fed from the three-phase current system of the local power house, no unfavorable influence having ever been noticed. Into the high-tension circuit of the transformer are inserted a voltmeter and an ammeter, and each of the three conductors leading to the surface electrodes comprises an ammeter *A* (Fig. 1). Between the three surface electrodes are inserted three voltmeters *V*, and three other voltmeters $V_1$ indicate the voltage between each of the surface electrodes and the corresponding bottom electrode. Finally, the tension between the bottom electrodes can be checked by three voltmeters $V_2$. Each phase of the low-tension circuit comprises a wattmeter.

The booster transformer having an output of 150 kilowatts, is in its primary circuit likewise connected up to the 6,000 volts three-phase current system of the power house. As the current intensity at the low tension end depends on the variable resistance of the bottom (floor) material and the temperature of the bath, the booster transformer is designed for two

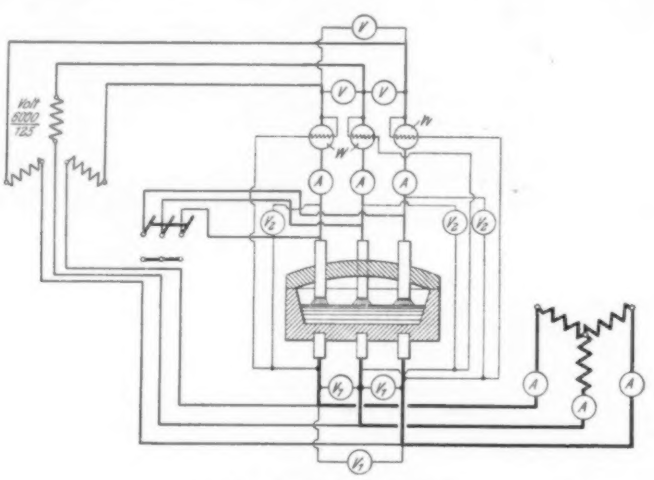


FIG. 1.—DIAGRAM OF CONNECTIONS

tappings for each low-tension phase, and is adapted to be connected up in triangle or star arrangement for each of these tappings, thus allowing 16.2, 19, 22, 28, 33 or 38 volts secondary tension to be derived, with a primary tension of 6,000 volts. An ammeter is fitted into each conductor leading from the booster transformer to a bottom electrode.

As regards, next, the furnace itself, this is designed for a capacity of five to five and a half tons of liquid steel. It is extremely simple in construction, and is tilted by hydraulic means. The furnace proper consists of two parts, the hearth and a removable lid, both of which are surrounded by a sheet metal sleeve. The outside diameter is 8.96 feet, and the height 2.20 feet.

The furnace comprises three doors (two arranged laterally and one at the discharge opening), which insure a ready view of the whole bath surface, thus facilitating the introducing of flux material, discharging of slag, etc. These doors are distributed over the spaces between the electrodes. The three cast-steel bottom electrodes are fitted into the floor from underneath, while the whole of the furnace body otherwise is entirely disengaged. Its center of gravity is so arranged that the furnace may tilt of its own accord only in a backward direc-

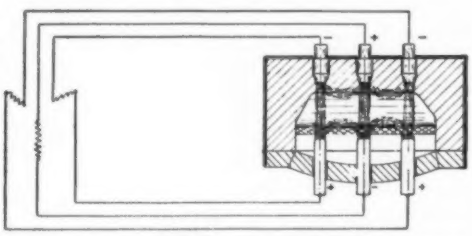


FIG. 2.—DIAGRAM SHOWING ARRANGEMENT OF ELECTRODES IN THE THREE-PHASE CIRCUIT

tion, the platform acting as a stop, so that even in case of failure in the working of the tilting device, the steel will never flow out of the furnace of its own accord.

Three carbon electrodes, 6.56 feet in length and 0.82 foot by 0.82 foot in cross-section, enter the furnace through its walls. These electrodes are arranged at the corners of an equilateral triangle, being suspended from rails by traction cables and rollers. Twelve flexible copper plates are used to supply current to each of the carbon electrodes. Six cables from the main transformer and six cables from the booster transformer lead to each of the bottom electrodes, the lower part of which is cooled by a common cooling-water conduit. Each of the carbon electrodes is surrounded by a special cooling box.

The operation of the furnace is carried on as follows: After making up in the furnace a wood or coke fire for starting, the current is switched on so that the flux soon becomes conducting, after which the coke is scraped off and liquid steel poured in. Whenever the operation of the furnace is discontinued a similar process is resorted to, the furnace being left filled with incandescent coke.

The current consumption in the case of mild charges has been found to be about 1,700 to 2,000 kilowatt-hours for charges of five to five and a half tons, thus working out at 300 to 400 kilowatt-hours for each ton. While this figure is relatively high, it should be considered that mild charges naturally take a longer time to refine than hard charges. Though moreover local conditions in the tests were as unfavorable as could be, such charges have frequently been made with less than 300 kilowatt-hours to the ton.

No definite idea of the working expenses can so far be formed. The first cost of the five-ton furnace was found to be about 12,000 marks, and that of the electrical equipment, exclusive of the transformer or generator, but inclusive of cables, pole pieces, etc., about 15,000 marks. A chief smelter, a smelter, a boy and a man for regulating the electrodes were required to keep up operation. The life of the lid was found to be six weeks.

* Stahl und Eisen, No. 33, 1910.

## The World's Lead Supply

After having passed in review the world's production in reserves in coal, iron and copper, Prof. J. A. Kemp, in his paper, "Geology and Economy," goes on to treat in the same way the case of lead. We quote him in his own words:

"Among the nations of the world the United States has become the chief contributor of lead, and yields year by year proportions varying from 27 to 33 per cent of the total. The next country is Spain, with about two-thirds as much, and Germany follows with three-fifths.

"In this country the State of Missouri is the heaviest contributor, and is responsible for practically 40 per cent of the total. Idaho is next with about 32 per cent, and Utah follows with 13 to 14. The Western lead all carries silver. The precious metal is an important factor in the value of the product. When we come to forecast the future it is not possible to see more than a few years in advance or to speak in more than a general way. The miners would be glad to be assured of reserves of ore for a goodly period of years, but it is seldom possible or practicable to demonstrate their presence. Operations necessarily continue with a few years' supply blocked out in advance of the actual mining, and the hope is maintained that more will be found. Very often the expectations prove justified. We may therefore in a measure forecast future experience somewhat by the past. In the Missouri lead region mines have been operated for forty or fifty years, not on so large a scale at the outset as now, but continuously. For some years at least no change may be anticipated. In Idaho the lead ores are now known to continue to depths of nearly 2,000 feet beneath the overlying surface, and to be holding out without essential change in character. In Missouri, however, the mines never have been very deep, that is, over three or four hundred feet, and the compensation comes in wide horizontal extent.

"Some of the old-time heavy producers have greatly declined. Nevada, once an extremely important source of lead, is now a comparatively small contributor. Colorado, in former years our chief source, has dropped to only a third of its one-time yield, and yet the total of the country has gone quite steadily on. The fall in the price of silver was a hard blow to the Western lead miners, and naturally not only cut off their profits, but raised the necessary percentage of metal in the ore.

"If we look ahead for a century or some such long period, we may not feel assured that production can be maintained at present rates. There may, of course, be new discoveries in lands not as yet fully explored. Being distant from present centers of consumption as they necessarily would be, their entry into the markets would imply higher prices so as to meet the charges of freight.

"On the other hand, lead is a metal which oxidizes or changes very slowly. In its applications in the metallic state it tends thus to accumulate unless lost in use, as in the case of shot and bullets. It is extensively employed in the manufacture of paint, and in this form is of course never recovered. About 2 per cent of the entire output is destroyed to give us white and red pigments.

"It behooves us, on the whole, to be careful in the use of lead and to avoid, when possible, its unnecessary sacrifice."

## Ionization in the Electric Furnace.

An interesting apparatus was exhibited at the recent soiree of the Royal Society by Dr. J. A. Harker and Mr. C. G. Eden. In some experiments involving the treating of refractory oxides in the electric furnace, some curious effects were noticed indicating pronounced differences in the chemical activity at high temperatures of the atmospheres of two different electric furnaces. A miniature furnace of simple construction, suitable for temperatures to 3,000 deg. C., was shown working. It consists of a tube of arc-lamp carbon 14 millimeters external diameter, surrounded by a protecting sheath of pure lamp black, and heated by alternating current, passed through it from a small transformer. Entering the interior of the tube at each end, and insulated from it, is an electrode of carbon. One electrode is hollow, so that an optical pyrometer can be sighted upon it; the other is movable on a graduated scale. A battery of variable E.M.F. and electric measuring appliances serve to measure the amount of current sent across the gap at any temperature. In the larger furnace used, the resistance of the gap varies from infinity at ordinary temperature to an apparent value of less than an ohm at 2,200 degrees. At low temperatures such as 1,400 degrees a few volts give a "saturation current." At high temperatures the saturation current reaches 8 or 10 amperes. The phenomena are not those of an arc, and are unaltered by passing an indifferent gas through the furnace.

# The Wastes of a Blast Furnace*

## How They are Utilized

By Edward M. Hagar, President, Universal Portland Cement Company, Chicago

Until the last decade, practically the only utilization of the wastes or by-products of a blast furnace was the use of a portion of the waste gases to raise the temperature of the incoming blast through heating the brick work in so-called hot stoves, and in some cases a small portion of the power value of the gases was obtained by burning them under boilers to generate steam for driving the blowing engines.

At the present time the calorific value of the waste gases is being utilized directly in gas engines for blowing purposes and for generation of electric power, a considerable portion of the slag is used in the manufacture of Portland cement, and the flue dust, consisting of the finest ore and coke particles, is being collected and converted so as to be rechargeable into the furnaces.

The aggregate saving or profits resulting from these three developments is a matter of millions of dollars per annum, and in a modern blast furnace plant it would almost seem that pig iron was the by-product; and, indeed, the investment in the equipment to utilize these former wastes exceeds that of the blast furnace itself.

The writer, in his work, has come in contact with these evolutions, with plants in operation, or under construction, of a capacity to produce twelve million barrels of Portland cement per annum from slag and limestone, using over one million three hundred thousand tons of slag in a year, these plants being driven entirely by electric current generated by gas engines directly from the waste blast furnace gases, the power requirements being forty thousand horse-power for twenty-four hours every working day. In one of the cement plants the first commercial method for reclaiming flue dust was discovered.

By using the blast furnace gases directly in combustion engines, after suitable washing to remove the grit, the power obtained from a given amount of gas is equal to at least two and one-half times that obtainable by burning the gas under boilers for generating steam for use in steam engines.

A modern blast furnace of the usual size, with gas blowing engines, and gas engines driving electric generators, will provide sufficient gas to furnish seven thousand kilowatts electric power, in addition to driving its own blowing engines.

This permits the most modern steel works, such as those at Gary, Indiana, to practically do away with the use of coal for power purposes, operating the rolling mills by electric power from the surplus gases.

The United States Steel Corporation, of which the Universal Portland Cement Co. is a subsidiary, has already installed two hundred and fifty thousand horse-power gas blowing and gas electric units, which, it can easily be figured, displaces or saves the consumption of approximately a million tons of coal per annum as compared to the old-fashioned method.

With the modern high blast pressures, and the use of fine Missabe ore, the finest of the particles, together with the coke dust, are blown out through the top of the furnaces and are caught in the flues, dust catchers and gas washers.

The iron ore in this dust amounts to fully three per cent of the total ore charged, which aggregates the large amount of approximately a million and a quarter tons per annum in this country. Until within a few years this dust has been thrown away or used as filling, although containing about forty per cent metallic iron.

For many years efforts were made to use this material by compressing it into briquettes, but the cost of the operation, together with the fact that the briquettes disintegrated and the dust was again blown out, led to an abandonment of the briquetting plants.

The first commercially successful method of utilizing the dust was discovered by passing the material through the cement kilns at South Chicago. Experiments showed that with the proper heat treatment, the coke dust could be burned off and the iron ore conglomerated into nodules or nuggets averaging over sixty per cent iron content. These nodules, when fed to the blast furnace, were easily and completely reduced. The fact that the sinter of the flue dust contains such a high percentage of iron and that all of the sinter is reduced, together with its physical shape assisting the steady movement of the charge downward in the blast furnace, thereby preventing so-called slips, makes the sinter more valuable per ton than any ore.

* Presented before the Congress of Technology at the fiftieth anniversary of the granting of the charter of the Massachusetts Institute of Technology.

It was necessary to derive mechanical means for preventing the accumulation of the sinter on the walls of the kiln. Plants have been in operation for some years using this process, with endless chains carrying scrapers constantly passing forward through the kiln, and cooled in water on their return outside of the kiln.

Recently other methods of utilizing dust have been devised which may prove successful commercially, and the indications are that within a short time the greater portion of this former waste will be prevented.

The development of the Portland cement industry in this country and the extension of its uses have been marvelous, and the following table shows a remarkable increase in the production of Portland cement in the United States every year since 1895, when this country first reached the production of approximately one million barrels:

| Year. | Production of Portland Cement of United States. Barrels. | Production of Universal Portland Cement. Barrels. | Percentage of Universal to Total American Production of Portland Cement. Per Cent. |
|---|---|---|---|
| 1895 | 990,324 | —— | ... |
| 1896 | 1,543,023 | ...... | ... |
| 1897 | 2,677,775 | ...... | ... |
| 1898 | 3,692,284 | ...... | ... |
| 1899 | 5,652,266 | ...... | ... |
| 1900 | 8,482,020 | 32,443 | 0.39 |
| 1901 | 12,711,225 | 164,316 | 1.29 |
| 1902 | 17,230,644 | 318,710 | 1.85 |
| 1903 | 22,342,973 | 462,930 | 2.08 |
| 1904 | 26,505,881 | 473,294 | 1.78 |
| 1905 | 35,264,812 | 1,735,343 | 4.92 |
| 1906 | 46,463,424 | 2,076,000 | 4.55 |
| 1907 | 48,785,390 | 2,129,000 | 4.36 |
| 1908 | 51,072,612 | 4,535,000 | 8.89 |
| 1909 | 62,508,461 | 5,786,000 | 9.27 |
| 1910 | 73,500,000* | 7,001,500 | 9.52 |

* Government estimate.

It may be of interest to note the increasing percentage of the total American production shown by Universal Portland cement, which is the only Portland cement manufactured in this country using slag as one of the raw materials. With the new plant now approaching completion the aggregate production of Universal Portland cement in the Chicago and Pittsburg districts will amount to over one-eighth of the country's total. Expressed in weight, the output of the finished product will be over two million gross tons per annum. Our plants in the Chicago district will consume all the available slag that is suitable for the purpose from an aggregate of nineteen blast furnaces in the South Chicago works of the Illinois Steel Company and in the Gary works of the Indiana Steel Company.

Comparing the pig iron production and Portland cement production of this country in figures of long tons, the percentage of Portland cement to pig iron in 1890 was six-tenths of one per cent, in 1900 ten and three-tenths per cent, and in 1910 forty-seven per cent. The continuation of any such relative growth would mean that before 1920 the tonnage of Portland cement would considerably exceed that of pig iron. I would hesitate, however, to predict that such would be the case.

Portland cement is defined by the United States government as the product obtained from the heating or calcining up to incipient fushion of intimate mixtures, either natural or artificial, of argillaceous with calcareous substances, the calcined product to contain at least one and seven-tenths times as much of lime, by weight, as of the materials which give the lime its hydraulic properties, and to be finely pulverized after said calcination, and thereafter additions or substitutions for the purpose only of regulating certain properties of technical importance to be allowable to not exceeding two per cent of the calcined product.

From this definition it will be seen that the raw material for Portland cement is not limited to any particular form of material, it may be made from any combination of materials that together furnish the proper elements. In this country Portland cement is manufactured from a number of raw materials, which, with a few exceptions, may be classed under four heads:

First. Argillaceous limestone (cement rock) and pure limestone.

Second. Clay or shale and limestone.

Third. Clay or shale and marl.

Fourth. Slag and limestone.

In all cases the raw mixture is a combination of some form of clay and some form of lime, and in the first and fourth classifications the clay materials contain some lime. This simply reduces the proportion of lime material necessary for a proper mixture.

In the manufacture of Portland cement from slag and limestone, the molten slag flowing from the furnaces is granulated by a stream of water, loaded into cars and transported to the cement plants, where it is dried in rotary driers, and receives the first grinding. It is then mixed in automatic weighing machines, with the proper proportion of ground and dried calcite limestone. These are then ground together and burnt to a hard clinker at a temperature of nearly 3,000 deg. F. in rotary kilns, using pulverized coal for fuel.

This clinker, after seasoning, is crushed and ground and mixed with a small percentage of gypsum to regulate the setting time. The cement is ground to such fineness that ninety-six per cent passes through a sieve having ten thousand meshes, and eighty per cent passes a sieve with forty thousand meshes to the square inch. It is then conveyed to the stock house for storage prior to shipment.

It is necessary to use a flux in furnaces supplying slag for cement manufacture, a pure calcite limestone. The limestone burnt with the slag must also be a pure calcite stone. It is also essential that the ores be of a uniform and proper character.

Inasmuch as Lake Superior ores are noted for their remarkable uniformity of analysis, the resultant slag obtained from the use of these ores and a pure calcite limestone is more uniform in its analysis than any form of natural clay deposit used in the manufacture of Portland cement, and the variation in the proportions of the two raw materials used in the manufacture of Portland cement from slag is less than those of any other materials mentioned above.

In addition, the opportunity for analysis and selection of the proper ingredients through the use of an artificial material is a great advantage as compared to the necessitous use of natural materials just as they are found with their variations in analysis at different depths.

In the intense heat of the kiln, under the influence of the oxidizing flame, any sulphides in the slag are completely burned out.

The rotary kiln commonly used ten years ago was sixty feet long and six feet in diameter. This has gradually been increased in length and diameter until the modern kiln is one hundred and forty to one hundred and fifty feet long and eight to ten feet in diameter, and there are a few even larger kilns in use. Kilns are usually set at an incline of three-quarters of an inch to the foot. With the lining and contents the modern kiln weighs one hundred and fifty tons, and in revolving upon two bearings presents interesting constructional features.

In the case of the plant at Buffington, Indiana, using twenty-six thousand horse-power, situated between South Chicago and Gary, Indiana, electric power is supplied at twenty-two thousand volts from the steel works at these points. Each piece of machinery is driven by its individual motor, supplied with alternating current at four hundred and forty volts. The high tension line is connected through the cement plants, and the gas engines at these two steel works, fourteen miles apart, operate continually in parallel. This enables the cement plant to draw its power from either source, or from both sources at the same time, as may be desirable. It has happened that one of these works has supplied power to operate the cement plant and furnished additional power at the same time to the steel works at the other end of the line.

The method of manufacture above described is the standard method of manufacturing Portland cement from natural deposits, and the finished product differs in no way from other Portland cements in chemical analysis, fineness, specific gravity, color, nor in the operation in practical work. It has no peculiarities whatever and has no limitations as to its applications. There is no difference, from the chemist's point of view, between the manufacture of Portland cement from natural deposits, such as limestone and clay or shale, and its manufacture from limestone and slag. Slag is really a mixture of the clay from the ore with the lime content of the stone used as a flux in the furnace.

Our method of manufacture of Universal Portland

cement does not embody any real invention, nor is it based on any patents. It is simply an adaptation to an artificial raw material of the regular Portland cement process formerly applied only to natural deposits.

True Portland cement in which slag is used as one of the raw materials should not be confused with Puzzolan or so-called "slag cements" which are simply mechanical mixtures of slag and slaked lime ground together without burning. Such cements are suitable only for use under ground and in moist locations.

The manufacture of Puzzolan cements in this country has practically been abandoned.

The remarkable growth of the Portland cement industry is not equalled by any other manufactured article. This is due to the economy, durability, and plasticity of cement and concrete work. While large engineering work, such as dams, bridges, and heavy reinforced concrete buildings, consume large quantities of cement, the bulk of consumption at the present day is in a multitude of small uses. It takes an average shipment of only five barrels a day to take care of the average customer of a large cement company.

For example, there is a steady increase in the application of cement to new uses on the farm, such as silos, fence posts, barn floors, feeding floors, watering troughs, corn cribs, etc. There, as elsewhere concrete is rapidly displacing all forms of wood construction, this process being hastened by the continually advancing cost of lumber.

Beautiful effects are now being obtained in concrete surface finishes, and its use in decorative work is advancing rapidly.

The use of Portland cement will continue to increase until the campaign of education of the small user has reached its finality. In this direction a great work is being done to educate the general public in the proper use of cement by individual manufacturers, by the Association of American Portland Cement Manufacturers, and by the cement shows which are given in several of the largest cities every year.

In conclusion it will be seen from the foregoing that most of the problems of utilization of wastes or by-products of the blast furnace have been solved, and that these solutions in addition to being highly profitable, are powerful factors toward the conservation of our natural resources.

Portland cement manufactured from slag, to a large extent, replaces wood; the waste gases displace coal, and reclamation of the flue dust conserves the deposits of iron ore.

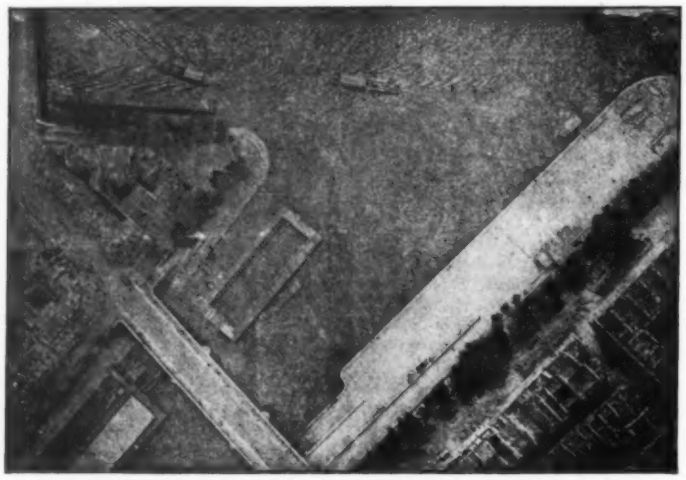
# Determining Aeroplane Altitudes*

## How a Machine's Height is Measured

By Henry Harrison Suplee

Measurements of altitude are usually more difficult of precise determination than those made at or near the surface of a comparatively level country. This is evident in connection with the frequent revisions which have to be made of the altitudes of mountain peaks, and it becomes especially apparent when the true height attained by an aeroplane is to be determined.

The early performances of flying machines were comparatively limited, so far as altitude was concerned, the height above the surface being little more than was necessary to insure safe clearance above trees, buildings and similar obstructions. It is only within the past year that altitudes of several thousand feet have been attained; but since the aviators have succeeded in acquiring greater control over their machines, and have themselves discovered that no serious difficulty attends the conduct of flights in the upper air, there has arisen a competition among sporting airmen to secure the "record" altitude, which demands some reliable method for measurement of the true position above the surface of the earth. Apart from the desirability of determining the correct height attained in any such competition, it is also extremely important to be able to measure the correct position of an enemy in the air as soon as the aeroplane enters the domain of warfare. The range must be obtained if the special aerial guns are to do effective work, while knowledge of the true altitude is also most desirable in connection with the work of the scouting aviator.



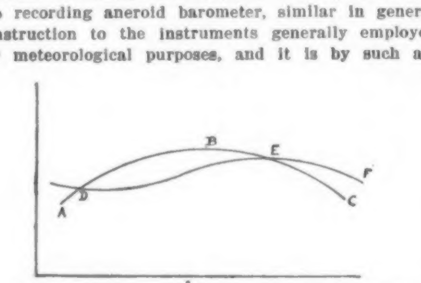
PHOTOGRAPH OF ISLE ST. LOUIS, TAKEN FROM BALLOON

The known distance between river banks and the known focus of lens enable altitude to be computed.

Several requirements must be met in considering satisfactory solutions of the problems connected with aerial altitude measurements. Broadly, two fundamental methods have to be considered: one in which the apparatus employed is carried in the aeroplane itself, the other in which the measurements are made by the use of instruments observing the flying machine from the ground. These, again, may be divided into methods which enable the altitude to be determined immediately and continuously, and those which require subsequent computations to be made from the observed data.

The older aeronauts usually depended upon the barometer as an indicator of altitude, and with the sustaining power of a large balloon and the opportunity afforded of consulting such an instrument carefully a certain degree of precision was obtained, especially when a high-grade mercurial barometer was carried, and simultaneous readings were taken on the surface of the earth. Even with a carefully calibrated aneroid, compared with a standard instrument immediately before and after the trip, the altitude attained might be fairly well determined, provided the rate of ascent and descent of the balloon was not too rapid.

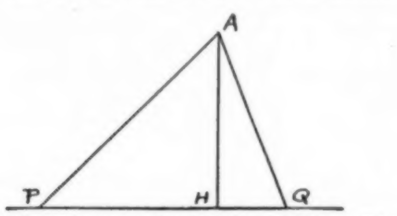
In the case of the aeroplane, however, the conditions render it impracticable to use a mercurial barometer, while the demands upon the operator's attention preclude the possibility of visual readings and records. Reliance, therefore, has to be placed upon the recording aneroid barometer, similar in general construction to the instruments generally employed for meteorological purposes, and it is by such apparatus that most of the published altitudes attained by aeroplanes have been determined.




CURVES SHOWING LAG OF BAROGRAPH RECORD

Records of this kind, however, must be accepted with caution, and should be carefully checked, whenever possible, because of the conditions under which the instruments are obliged to act are hardly conducive to a very high degree of precision.

A brief examination of the construction and action of the aneroid barometer will show why this is so. The aneroid barometer is really a special form of pressure gage, intended to measure external pressures generally less than the ordinary atmospheric pressure at sea level. The pressure gage, as usually employed in engineering work, is employed to determine pressures maintained in closed vessels, such as steam boilers, reservoirs of compressed air, or of water under pressure, and the like, and it is not difficult to make suitable connection and lead the pressure fluid into some kind of a closed chamber in the instrument and utilize the dilatation or other movement of the walls of the chamber to indicate the variations in pressure. In the case of the barometer, however, the pressure fluid is the external air, and the arrangement of parts must be practically reversed. This is effected by employing a small chamber, usually cylindrical in form, somewhat like a short drum, the top and bottom being corrugated in order to permit a certain amount of movement. If the air be exhausted from such a chamber the tendency will be for these corrugated ends to collapse together under the external pressure of the air, and if this tendency is opposed by a spring of sufficient strength to hold the ends apart, the apparatus will be in equilibrium so long as the pressure of the external atmosphere remains constant. If the external pressure increases, the corrugated ends will move together, while if the pressure decreases the force of the spring will pull them further apart. The combination,




TRIANGULATION METHOD FOR DETERMINATION OF ALTITUDE

therefore, will respond at all times to the variations in atmospheric pressure. It is evident that the amount of movement permissible is limited by the elasticity of the metal and by constructive details, and that it is in all cases very small.

It is necessary, therefore, to use some method of multiplying the motion in the "vacuum box," as it is termed. In the ordinary dial barometers of the Naudet type this multiplication of motion is effected by the combination of levers and of watch-chain, often visible through the opening in the front, while in the recording barometers of the Richard design recourse is had to the use of several vacuum boxes built up together in such a manner as to secure the accumulated movement of all, this increased movement being also multiplied by leverage. A pencil attached to the end of the lever enables the vertical movement to be recorded upon ruled paper, and if this paper is kept in motion at right angles to the pencil movement by means of clockwork a curve of pressures will be automatically described. It is an instrument of the latter type which has been used in most of the recent altitude flights of aeroplanes.

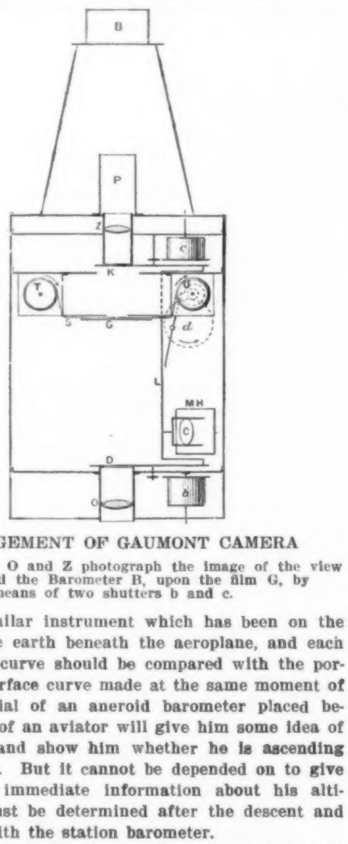
The great difficulty in obtaining reliable records with such a barometer lies in what may be termed its "lag." As will be perceived from its construction, a certain amount of *time* is required for the mechanism to respond to changes in external pressure. This lag is due not only to the movement of the vacuum box itself, but also to the frictional resistance and inertia of the multiplying mechanism—and, indeed, it is principally caused by the latter. The result is that the instrument does not respond quickly enough to follow

* Reprinted from *Cassier's Magazine*.

rapid changes in altitude. This may readily be demonstrated by carrying an aneroid barometer in the hand while making a rapid ascent in the express elevator of a tall building. The pointer will be seen to fall for some little time after the elevator has reached the top of its run, showing that an immediate reading would have been erroneous. In mountain ascents and similar measurements this error is eliminated by giving sufficient time for the instrument to catch up with the pressure changes, and under such conditions very precise altitude determinations may be made, but this is impracticable in the case of the aeroplane.

The extent to which this lag may affect the indication of a recording aneroid barometer is seen in the diagram. If the curve *A*, *B*, *C* indicates the actual pressures of the atmosphere and the transition be rapid, the recording barometer, which may be correct at the point *D*, will not rise quickly enough to trace the true curve, and will still be rising when the correct curve has begun to fall, so that the record on the paper of the instrument will be something like *D*, *E*, *F*, different both in form and position from what it should be. Such a deviation from the truth will be greater or less, according to the rapidity in the change of altitude. In general, it may be accepted that the recording barometer as at present constructed may show the correct height of the aeroplane by which it is carried if the machine soars at a fairly constant height for a moderate time—probably half an hour would be ample—but that under more rapid altitude changes it will indicate a lower altitude than the true one.

In any case, it is impracticable to obtain a reliable determination by the direct reading of the instrument alone. The reading should always be compared with



ARRANGEMENT OF GAUMONT CAMERA

The two lenses O and Z photograph the image of the view beneath and the Barometer B, upon the film G, by means of two shutters b and c.

that of a similar instrument which has been on the surface of the earth beneath the aeroplane, and each point on the curve should be compared with the portion of the surface curve made at the same moment of time. The dial of an aneroid barometer placed before the face of an aviator will give him some idea of his altitude, and show him whether he is ascending or descending. But it cannot be depended on to give positive and immediate information about his altitude; this must be determined after the descent and comparison with the station barometer.

It is true that there are certain types of aneroid barometers, notably the improved instruments of the Goldschmidt pattern, which are notably free from lag, owing to the direct connection between the vacuum box and the indicating arm; but these instruments have, as yet, not been made in the recording form, and require careful and precise ocular readings to be taken and the altitude subsequently computed. While especially well adapted for mountain service and for the measurement of altitude determinations upon the surface of the earth, they have not, as yet, been adapted to aeronautical purposes. It is probable that a barograph, combining the accurate indications of the Goldschmidt barometer and the convenience of the well-known disk recording pressure gage, may be constructed for this purpose.

The suspension of a barograph when carried in an aeroplane is a matter which demands attention. Vibrations, in themselves, are rather beneficial than otherwise in the use of an aneroid barometer, and it is desirable that the ordinary instrument should be tapped before a reading is taken, in order that the frictional resistance of the pivots and other working parts may be overcome. The continual trembling of the aeroplane motor, however, introduces vibrations into the record curve, which may become periodical and excessive unless the instrument is carefully suspended. M. Latham suspends his barometer from his neck, but a better plan is that devised many years ago by the late Col. Renard, the case of the barograph being placed within a bamboo cage and held suspended in space by a number of rubber bands. It

PHOTOGRAPH TAKEN IN GAUMONT CAMERA, SHOWING BAROMETER DIAL UPON VIEW

has been shown that an instrument thus suspended may be allowed to drop from a height of 10 or 15 feet to the ground without injury. Barographs fitted in this manner have been successfully used upon the *ballons-sondes*, or free exploration balloons, sent out for meteorological investigations.

Optical methods, employed from the aeroplane itself, are necessarily limited, since they usually demand more attention than can be given by the operator himself, and require the service of an independent passenger. The principle is that of the well-known artillery range-finder, the observer in the aeroplane sighting upon two points on the ground, and reading the corresponding distance on the scale of the instrument, whence the proportionality of similar triangles gives the altitude; or the scale of the instrument may be so graduated as to enable the altitude to be read directly.

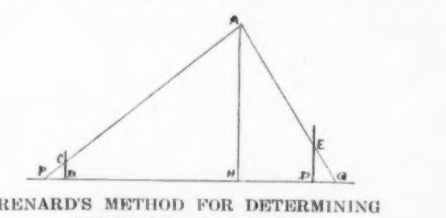
This principle, however, may be still further extended by the use of the apparatus already fully developed for the operations of "photogrammetry," or photographic surveying.

The idea of taking photographs from a balloon appears to have originated with Nadar as long ago as 1855, but it was not until the perfection of the gelatino-bromide dry plate, and the consequent possibilities of instantaneous photography, that practical results were obtained. Attempts were made in France, in 1878, by Dragon and by Triboulet, and in 1880 by Desmarets, while in 1883 some very successful photographs were taken in England by Shadbolt. Photography from balloons thus became recognized as a valuable adjunct, especially in connection with military observations, and its possibilities have by no means yet been exhausted.

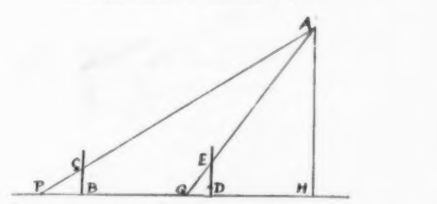
The excellent work which has been done by French topographers, notably by Col. A. Laussedat, using cameras of special design, arranged so as to enable several correct perspective views to be combined into a single topographical map, shows what may be done when a direct plan can be photographed from above. Already the camera has been arranged to permit photographs to be taken from observation kites, and a similar apparatus is adaptable to the aeroplane.

By having a ruled screen placed within the instrument so that the lines are photographed upon the film at the same time as the surface of the earth beneath, the scale of the picture may readily be determined in connection with the known focal length of the lens, and thus the only element required to be known is the true dimensions of some object in the picture. In the case of the altitude record trials the use of certain clearly marked monuments on the field furnishes the necessary information, and the proportion between the true distance between two stripes on the field and their distance on the photograph will give the relation between the focus of the lens and its height above the ground. When no predetermined base is visible it may still be possible to find out subsequently the dimensions of some building or other object in the picture, and thus enable the altitude to be computed. Several years ago M. Gaumont devised an ingenious combination of camera and aneroid barometer, so arranged that the dial of the barometer was photographed upon each picture, thus furnishing a record of the altitude at which each negative was taken. This method involves the general objections to the use of the aneroid which have already been mentioned, but the plan has wide possibilities in connection with probable improvements in barometers for this purpose.

An ingenious plan which has been suggested for measuring the altitude of an aeroplane, and which, while it requires the services of an independent operator, demands no other apparatus than an accurate stop-watch, is the acoustic method. Any sharp sound, such as a quick whistle, or a report which may be differentiated from the noise of the machine itself, will be returned to the ear of the operator in the form of an echo from the surface of the earth. If, therefore, the time elapsing between the sound and the echo be noted, the corresponding distance may be estimated from the known velocity of sound. Taking the velocity of sound at 1,100 feet per second, or a little more than 100 feet for a tenth of a second, and remembering that it is the double distance, going and returning, which is thus computed, the error of observation would be between 50 and 60 feet for one-tenth of a second. This method is also liable to variations, due to differences of temperature and of layers of variable density in the atmosphere, and is more available for a quiet balloon than for a noisy aeroplane.

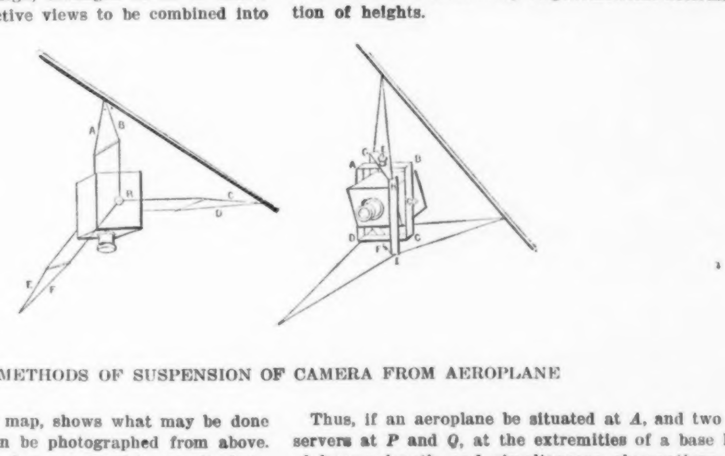


RENARD'S METHOD FOR DETERMINING AEROPLANE ALTITUDES



RENARD'S METHOD WHEN AEROPLANE PASSES BEYOND OBSERVERS

In the second kind of observation, those made from the surface of the earth, the operations are similar to those used in the ordinary trigonometrical determination of heights.



METHODS OF SUSPENSION OF CAMERA FROM AEROPLANE

Thus, if an aeroplane be situated at *A*, and two observers at *P* and *Q*, at the extremities of a base line of known length, and simultaneous observations are made of the angles *A P Q* and *A Q P*, the triangle will be completely determined, and the height *A H* may be computed. If the observers are directly beneath the aeroplane the altitude will be obtained very simply, but this is rarely the case. It will, therefore, usually be necessary to make three simultaneous observations from as many known points, from which the true height may be obtained.

At the Harvard-Boston Aero Meet in September, 1910, trigonometric measurements were made with a

base line of somewhat more than 6,000 feet. The operators were provided with standardized watches, to enable tally to be kept of the observations, and with head and breast-attached telephones, to enable the word to be passed for the moment of the simultaneous observations. Since transit instruments were employed, it was possible to measure both vertical and horizontal angles, and thus the results were obtained with but two observing stations. For ordinary angular measurements of this sort the sextant has also been employed, but the precision is necessarily lower than with the transit.

Another method, suggested by Commander Paul Renard, may be applied under certain conditions. Two observers are placed at points $P$ and $Q$, the distance $P$—$Q$ between them being known, and it is also being known that the flight of the aeroplane will pass over some point vertically over the line between $P$ and $Q$. The two observers are furnished with instruments which enable them to measure the apparent height. In the absence of sextants, or other instruments of precision, a simple substitute may be found in the form of rods placed at $B\ C$ and $D\ E$, these being erected as nearly vertical as possible and at points at which the distances $B$—$P$ and $D$—$Q$ are known. These rods should be graduated so distinctly as to be easily read by the observers, and it is essential that $P\ B$ and $D\ Q$ should be on the same alignment. The observers are to be instructed to watch for the passage of the aeroplane and to read the apparent point at which it crosses the graduated rods at the moment when it passes over the base line. With these readings and the knowledge of the distance between the two observers, the altitude of the aeroplane may be computed as follows: From the two sets of right-angled triangles we have

$$\frac{P\ B}{C\ B} = \frac{P\ H}{A\ H}$$

and also

$$\frac{Q\ D}{E\ D} = \frac{Q\ H}{A\ H}$$

By adding these two equations together we get

$$\frac{P\ B}{C\ B} + \frac{Q\ D}{E\ D} = \frac{P\ H + Q\ H}{A\ H} = \frac{P\ Q}{A\ H}$$

In this formula we have the quantities $P\ B$, $Q\ D$ and $P\ Q$, already known, while the single unknown, which may thus be determined, is the altitude $A\ H$. This method, it will be observed, is independent of the particular values of the horizontal distances $H\ P$ and $H\ Q$—that is, the aeroplane may pass anywhere over the line between the two observers, provided the corresponding readings on the two graduated rods are correctly taken. It is desirable, however, that the aeroplane pass between the observers, although readings may be taken if it should pass beyond them, as shown in the figure. With experienced observers this will give fairly good results, since the men will secure approximately simultaneous readings. The principal defect is that it gives the height over some undetermined point $H$, and hence it is well, if possible, to have the whole system arranged upon a fairly level plain.

When a trial for an altitude record is made upon this plan, the aeroplane may circle above the base line and its height taken every time it cuts across the line, the observations being numbered, to enable the proper ones to be paired.

In many cases, especially in warfare, it is the distance between the observer on the earth and the machine in the air which is desired. This is really a problem in range finding, and the principles are well known.

At the camp of Chalons the Souchier telemeter was used with a fair measure of success. The instrument consists of two telescopes, of which the objectives are fixed at one meter apart and the images brought together by reflectors, so that measurement is made of a very acute triangle, the aeroplane being at the sharp apex opposite the base of one meter.

It will be seen that at the present time there is no method which is entirely satisfactory for general use. Trigonometrical observations from the ground, while the most accurate, require much previous preparation, practicable only during some exhibition or sporting event, and, possibly, capable of permanent installation in important fortresses liable to attack, but otherwise inapplicable for lack of time and need of suitable apparatus.

The photographic methods require, in general, the services of an additional operator, although it is possible that an automatic device may be produced. In any case, it does not furnish its report until after the flight is over and the film developed, and hence its usefulness is limited to the production of a subsequent record of the trip. It may well be investigated, however, in connection with the substantiation and verification of altitude records made by other methods.

There remains the barometrical method, and, while this is at present lacking in precision, it offers the greatest opportunities for improvement and development. In view of the high degree of precision attained in the determination of mountain altitudes by aneroid barometers of the Goldschmidt type, it seems altogether possible that some improved variety of barograph will be produced in response to the demand which the aeroplane is making.

# Sugar Refining*

## The Processes of Manufacture

### By W. D. Horne

Just as sugar made from the cane appears first to have been used in the Orient and to have followed a westerly path, so we find the art of refining had its origin in the East and progressively traveled westward. Although the sugar cane was in use in India as early as the fifth century B.C., we learn of refining having been practiced first about 500 A.D. in Mesopotamia. A large trade in refined sugar gradually developed between the Orient and Europe, and in 1470 a certain Venetian was awarded a government payment of 100,000 crowns for discovering a process of refining sugar, which was from that time extensively carried on in Venice. In the sixteenth century Antwerp led in the sugar trade in Europe and in the refining industry. England began refining sugar in 1544 and gradually gained the supremacy over the other European countries in the industry. With the development of refining in Europe, the price fell from two shillings per pound in the thirteenth century to four pence per pound in the sixteenth century. This undoubtedly was partly due to the general introduction of the sugar cane into the West Indies from 1510 to 1650, and the consequent enormous production of sugar and its ever growing commerce.

As early as 1689 there was a refinery in New York city, and by 1795, New York, Philadelphia and Boston refined about 1,200,000 pounds of sugar yearly out of the 60,000,000 pounds which was annually consumed, being about two per cent of the entire amount. Refined sugar was heavily protected by duty and sold at 20 cents per pound. By 1860 there were forty-one refineries in the United States, producing $42,-000,000 worth of sugar annually. Now there are about half as many refineries, turning out three million tons of sugar annually, worth about $300,000,000.

In 1747 Margram succeeded in obtaining 6.2 per cent of sugar from beets, and Achard established the first beet sugar factory in Austria in 1769. Napoleon, to encourage the industry on account of the difficulty in obtaining sugar because of the blockade of the French ports during the wars, heavily subsidized the industry in France about the beginning of the last century. It gradually spread over Europe. The first experiments in beet sugar manufacture in the United States were made in 1830, and again some beet sugar was made in California, Illinois and Wisconsin during the period from 1863 to 1876. Claus Spreckles built a factory in 1870 at Alvarado, Cal., which was the first to meet with pronounced success. The industry has developed considerably since then, until there are now sixty-four factories, located principally in the western States and Michigan, with a total output last year of 457,000 tons, being 13.92 per cent of the consumption of the country. By 1900 the production of beet sugar had so increased that it had grown to be 60 per cent of the world's sugar supply.

In 1910-11 the world's sugar supply will be 17,-000,000 tons—50 per cent cane and 50 per cent beet. Sugar is produced also in small quantities from the sap of the date palm in some eastern countries. Prolonged attempts were made in this country some fifteen or twenty years ago to produce sugar from sorghum, but without success, as the dextrinous bodies in the sorghum juice prevent large quantities of the sucrose from crystallizing, and this plant is now used exclusively for the manufacture of syrup. The annual production of maple sugar in this country amounts to 6,000 tons, but as maple sugar owes its principal value to its pleasant flavor, rather than to its sweetness, it is always sold in its raw state, as refining it would rob it of half its present value and render it impossible of competition with cane or beet sugar. Milk sugar is produced to some extent and used, always refined, for medical purposes principally.

Sugar refining consists essentially in the purification of the crude crystalline material through the well-known process of re crystallization. To this we can add the second process of absorption of impurities by means of bone-black, first introduced by Derosne in 1812. By this means is affected a direct separation of impurities from the sugar solution and a large removal of the coloring matters, allowing of the more easy production of perfectly white crystals. While the process is relatively a simple one, and perhaps more mechanical than chemical in its nature, the enormous consumption of sugar in the country and keen competition in manufacture have led to the establishment of very large and elaborately equipped plants for the conduct of operations where every economy of procedure is carefully observed. The great amount of capital involved in erection and maintenance of such plants, together with the highly developed technique required for their operation has tended to keep the business in relatively few hands and to render it a dangerous enterprise for any but the most thoroughly equipped to venture upon. The sugar refineries of the country are in a few spots—New York, Philadelphia, Boston, New Orleans, San Francisco and Baltimore containing practically all of them. In 1910 the country consumed 3,350,355 long tons of sugar, practically all being refined. Of this amount 333,006 tons were cane sugar raised in Louisiana and neighboring States, 457,000 tons were beet sugar raised and refined during the process of manufacture in our western factories, 2,472,756 tons came from our insular possessions and Cuba, and 72,-393 tons came from other foreign countries. We imported practically no beet sugar and we exported practically no sugar at all. With the exception of Great Britain, the United States leads the world in the consumption per capita of sugar, this being 81.6 pounds per person. Most of this goes into direct use for household purposes, and yet enormous quantities are consumed by manufacturers of confections, preserves, condensed milk, as well as by canners of fruit, ice cream makers, soda water fountains and many other users.

As will be seen, the natural location for a sugar refinery is on the water front, where it can more economically receive and unload the great cargoes of sugar and of coal which come to it almost daily, for a modern refinery melts from a million to three or four million pounds of sugar per day. The economical handling of this vast amount of raw material and the successful guidance of so much organic matter in solution at high temperatures through long and complicated processes, without fermentation, decomposition, discoloring or waste is no mean accomplishment; but as in every other instance of manufacture the whole matter has been worked into a routine, which once properly installed, almost takes care of itself. As the sugar, whether in solution or later in granular form, has to pass through many operations in a continuous stream, as it were, it is thus found advantageous to have the units of a sugar refinery many stories high, so as to take advantage of gravity to pass these solutions from place to place or in delivering the dryer material from one department to another. This holds true equally of the bone-black, and we find the char house is usually a tall building in close proximity to the sugar house itself. In many instances the boiler house also has its coal bunkers in the upper story, allowing the fuel to feed by gravitation into the fire room or even upon the grates themselves. The high cost of real estate in cities also makes it advisable to extend upward rather than laterally. Each sugar refining plant will be found to have a large dock department for the receiving, weighing and storage of raw sugar, a boiler house for the generation of steam and evaporation, a wash house for the s[illegible] ing of raw sugars, the pan house for b[illegible]

* Yale Scientific Quarterly.

lating and other processes of manufacture of dry sugars, a char house for the accommodation of the bone-black filters, kilns for the re-burning of the char, etc., and usually a warehouse for the storage and shipment of refined products. These departments are not always built separately and frequently more than one of them will be found in the same building.

Somewhat different processes are used for the refining of beet and of cane sugar, but the difference consists principally in the method of defecation or clarifying the original raw sugar solution of its suspended impurities and part of its coloring matter. In either case the first operation is the unloading, weighing and storage of the raw sugar, whether in bags, baskets, mats, hogsheads or in other packages, in proximity to the melting department. A portion of the sugar is usually taken direct from the scales to the wash house, where the sugar is raised by a bucket elevator to an upper story and mixed with a low grade syrup while passing through a conveyor to the raw sugar mixer. The magma of raw sugar and syrup is fed from the mixing tank containing revolving arms into centrifugal machines, which purge the syrup from the sugar in a few minutes. Water sprinkled on effects the final washing, giving a sugar of high purity and a low syrup. This sugar is dissolved in a round melting tank with revolving arms in hot water to a density of about 30 Beaumé, pumped into blow-ups, treated with a very small amount of acid calcium phosphate and made slightly alkaline with milk of lime. Such a solution would boil at about 217.5 deg. F., and its temperature is next raised to something under 200 deg. F., whereby tricalcic phosphate is precipitated, entangling the suspended impurities and also removing, possibly by precipitation, some of the coloring matter. The lime has the effect of precipitating some of the gums and the heat at the relatively slight alkalinity precipitates most of the albuminoids. This process is applicable to cane or beet sugar or to a mixture, but in defecating beet sugar alone it is sometimes customary to add a few tenths of a per cent of caustic lime, precipitating this with carbon dioxide which precipitates suspended matters and largely removes the color. In either case the solution must be mechanically filtered. This is commonly done through cotton twill bags inclosed in woven sheaths. These are called Taylor filters. In the case of beet solutions the filter press is sometimes used, but this is not applicable to cane sugars which are gummy and sticky and clot the filter press. Beet sugar solutions are sometimes treated with sulphur dioxide after this preliminary alkaline defecation and again filtered in presses in a very faintly alkaline or neutral condition. The filter bags after becoming nearly exhausted are allowed to drain during several hours, are washed with hot water several times, allowing to drain between times, and are removed from the closed iron tanks in which they hang, for washing. They are turned inside out and rinsed in several waters, passing through wringers between them. The muddy water thus obtained still contains some sugar, and is pumped through filter presses, the sugar of the clear filtrate being recovered. The press cake, containing very little sugar, is discarded.

The clarified solutions are next filtered through bone-black, contained in cylindrical filters or cisterns. The liquor gives up the greater part of its color and a less per cent of its ash and organic impurities to the bone-black and is collected in storage tanks according to color and purity. Lower grade solutions of greater color follow the washed sugar solution on the char, so that the last filtrate from the char is pretty dark in color and much lower in purity.

The char filtered liquors pass to the vacuum pan, holding about 1,000 to 2,000 cubic feet, where it is boiled to grain and concentrated to a low water content.

This magma is dropped into the mixers or crystallizers, from which it passes to the centrifugal machines, where it is purged and washed with a spray of clear water, sometimes followed by a spray of blue water, formerly colored by ultramarine, which of late years has been replaced by harmless aniline colors prescribed by the government, since the pure food law put its ban on ultramarine as a mineral substance, not to be allowed in sugar products. The syrups can again be boiled in the vacuum pan to produce granulated sugar, and when the impurities and color accumulate enough the syrups are used for yellow sugars.

The moist sugar from the centrifugal machines, containing a small per cent of water, is passed through nearly horizontal revolving drums containing longitudinal shelves projecting inward which have the effect of picking up the sugar and sprinkling it through the current of warm air which is drawn through the opposite direction.

The sugar thus dried, next passes through revolving screens which separate it into different grades according to the size of the crystals, giving rise to granulated sugar, to be bagged or barreled.

In making cube sugar, some of this moist granulated sugar from the centrifugal is pressed into cubical blocks by an ingenious machine, and gently dried in ovens during a few hours. Cut cube sugar was originally made by draining the magma or boiled mass of sugar in conical molds for about two weeks, with occasional washing by means of pure sugar solution, sawing the dried cones into disks and cutting these across into cubes. A modified process of this kind is in use in Europe and to some extent in this country, in which the conical molds are supplanted by rectangular frames, which are purged in centrifugal machines in minutes instead of weeks.

Yellow sugars are made from low testing syrups, which are boiled in a vacuum pan and contain smaller softer crystals than higher grades of sugar, with considerable amounts of adherent mother liquor.

To return to the bone-black, this is washed down by hot water after the last sugar solution sinks below its surface and is thus freed from the sugar. Certain mixing of the water with the sugar solution is inevitable, giving rise to a zone of sweet water. As the water begins immediately to dissolve the impurities which the char had just absorbed from the impure sugar solution passed through it, this sweet water contains impurities along with the sugar and has to be separated from the main filtrate and treated by itself. The sugar washes out faster than the impurities, however, and when most of the sugar has been removed the stream of outgoing water is turned to the sewer, and continued until the char is pretty nearly free of what water can remove. The bone-black is then drained, emptied from the filter by gravity upon a dryer on the floor beneath, through which it passes to the kilns. These are furnaces provided with internal iron pipes, through which the char passes. By proper regulation of the flow of the char through these retorts its temperature is kept at a point which subjects the impurities still remaining in it to destructive distillation. Moisture, ammonia, carbon dioxide and other gases are given off, some of which are highly inflammable, leaving in the char a small residual amount of carbon. The char after cooling is then ready for use again and this entire cycle of operations is repeated.

When the carbon accumulates to such an extent as to choke the pores of the bone-black, the decolorizing power of the char diminishes, so that finally it must be discarded. Of late years this trouble has been obviated by the introduction of the Weinrich system of de-carbonization in which the char is passed through a roaster very much like the granulator before described and heated on the outside by direct fire to a suitable temperature. The air admitted suffices to burn off the impurities without attacking the carbon of the char itself in any marked degree. By this means char can be kept at a high point of efficiency for a considerably longer time.

The large amount of heat passing away from the char filters in the hot wash water is recovered by passing this water through tubulated heat economizers in which the incoming city water passes in the opposite direction, absorbing the heat of the outgoing water.

Water for sugar refining should be as soft as possible and as free from sulphates, iron, color and suspended matter as can be.

The sweet waters from the char are evaporated in multiple effect evaporators and usually mixed with other low grade solutions.

Fuel is an important matter in sugar refining, large quantities being used to generate steam for power purposes, evaporation and heating. This in large part explains why sugar is not refined where the raw product is made, the fuel cost being prohibitive.

The laboratory organization in a sugar refinery is a matter of great importance. It is the laboratory's function to keep track of the quality, not only of the raw and finished material, but also of the material in process of refining, not only to show the efficiency of each process, but to enable the most economical and expedient combination of the various liquors, syrups and other solutions throughout the process of refining so as to prevent unnecessary work and to indicate the most advisable method of handling. All raw sugars have to be analyzed in considerable detail, a close watch is kept on fuel, variations in the water supply must be noted, finished products must be kept up to the mark and waste products must be carefully checked up to avoid excessive loss. New processes have to be devised to meet varying condition and experimental work must always be pursued to keep up with the latest improvements and discoveries in the art.

The routine must go on day and night without cessation, and all chemicals, apparatus and other appliances must be properly standardized and those standards maintained. Analytical processes have to be investigated and tests devised for new needs. many materials entering into use in a large factory have also to be subjected to occasional tests or analyses and competent advice has to be given as to the desirability of new methods or processes, suggested from whatever source.

All this calls for an elaborate, competent and smooth running chemical organization. The routine tests, principally of purities, are conducted by young men carefully trained in this work and provided with every possible facility for its accurate and speedy accomplishment. In the laboratory many tests are made on char samples and wash water daily, all raw materials and waste products, all miscellaneous sugar samples, as those involved in stock taking, and so on.

The laboratory also keeps careful statistical records of all its various work and compiles elaborate monthly and yearly statements covering all these tests. The laboratory should be provided further with a good general chemical library and ample files of sugar journals as well as those of more general nature. A good laboratory should lead the work of the house, rather than follow it, by showing the way over difficulties that are from time to time bound to spring up; by inventing and elaborating new processes of more economical work; by keeping in touch with the outside world, and in general by assisting a smooth running of the entire enterprise.

## A Graphical Solution of the Quadratic Equation*

By Albertus Darnell.

Prof. Carl Runge of Göttingen, among other applications of graphical methods, mentions a very interesting solution of the quadratic equation. Prof. Runge, it will be remembered, was Kaiser Wilhelm Exchange Professor at Columbia University during the past year.

First consider the following graphical calculation for determining a line which shall represent the value of $f(x) = a_0 + a_1x + a_2x^2$ for some particular value of $x$.

Lay off $AB = a_0$, $BC$ perpendicular to $AB$ and equal to $a_1$, $CD$ perpendicular to $BC$ and equal to $a_2$. Now make $DE$ equal to the unit of measure, $EF$ perpendicular to $DE$ and equal to the value of $x$ for which we wish to compute the value of $f(x)$. Draw $GH$ perpendicular to [illegible]. $AH$ is the linear representation of [illegible] a [illegible]quals $EF$.

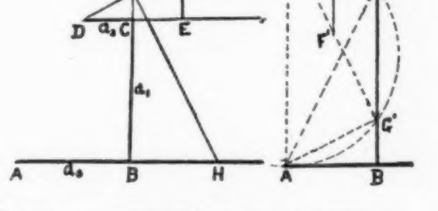
[illegible]ms that the triangles of the figure are [illegible]herefore we have

$x : CG = DE : a_2$.

Remembering that $DE$ is the unit, this gives $CG = a_2x$, and from this we have

$BG = a_1 + a_2x$.

$BG : DE = BH : x$.




Making the proper substitution, this gives $BH = a_1 + a_2x^2$, and from this we have $AH = a_0 + a_1x + a_2x^2 = f(x)$.

If the value of $x$ had been so chosen that the point $H$ had fallen at $A$ we should evidently have had a value of $x$ satisfying the equation $f(x) = 0$. This reduces the solution of the quadratic to the problem of constructing a right triangle on $AD$ as hypotenuse with the vertex of the right angle on $BC$.

The next figure shows the application of this method to the equation $2 + 5x + 2x^2 = 0$.

$EF$ and $EF'$ are respectively the roots $-\frac{1}{2}$ and $-2$, $DE$ being the unit.

The variations of the figure resulting from changes in the signs of the coefficients present no difficulty.

An account of the literature on the subject can be found in Encyklopädie der Mathematischen Wissenschaften.

* [illegible]ence and Mathematics.

**Shoe-sole Dressing.**—Mix over a slow fire 6,000 to 10,000 parts of linseed oil, 30 parts spermaceti, 15 parts of ceresine, 30 parts of resin and 30 parts of turpentine, apply the mixture warm to the soles of the shoes and the seams, rub off with a rag and dry at the stove.

# How Exporters Should Pack

## Suggestions from United States Consuls and Foreign Business Men

THE Bureau of Manufacturers of the Department of Commerce and Labor has in course of preparation and almost ready for the press, a monograph on Packing for Export which, from the viewpoint of the exporter, whether he be shipper of manufactured articles or of natural products, is one of the most important publications ever issued, for it marks the inauguration of a new propaganda, the preachment of the gospel of good packing, not from the standpoint of the shipper, but from that of the consignee, based on the consignee's knowledge of all the conditions at his end of the line, which will affect the goods or the materials in which they may be packed. The purpose of the monograph will be to tell the shipper just how the consignee wishes the goods packed. The consignee, from his experience, knows what style of packing will stand the handling the goods must receive, before reaching his particular point. He knows also the packing that will not reach his market in good condition.

As Mr. A. H. Baldwin, Chief of Bureau of Manufacturers, says in his letter submitting the monograph to the secretary:

"What is good packing for shipments to one country may be bad packing for another."

The volume therefore comprises letters from consular officers, including criticisms and advice, in the effort to help the American exporter.

The matter in the following and the accompanying illustrations are extracts from the proposed publication:

"It is said that flagrant cases of defective packing, due to the ignorance by Americans of business methods abroad and to the dependence of exporters on their own judgment in such matters have undoubtedly resulted in loss of foreign trade in many instances. No doubt the American manufacturer fails to realize that while he may sometimes save a few dollars at this end on a shipment, the buyer in foreign markets, by reason of lack of facilities to replace broken parts readily and cheaply, often has to pay out five or ten times what would have been the original cost in this country, or, failing to be able to duplicate, there is loss of time and interest on the value of the shipment for several months until parts can be brought from this country."

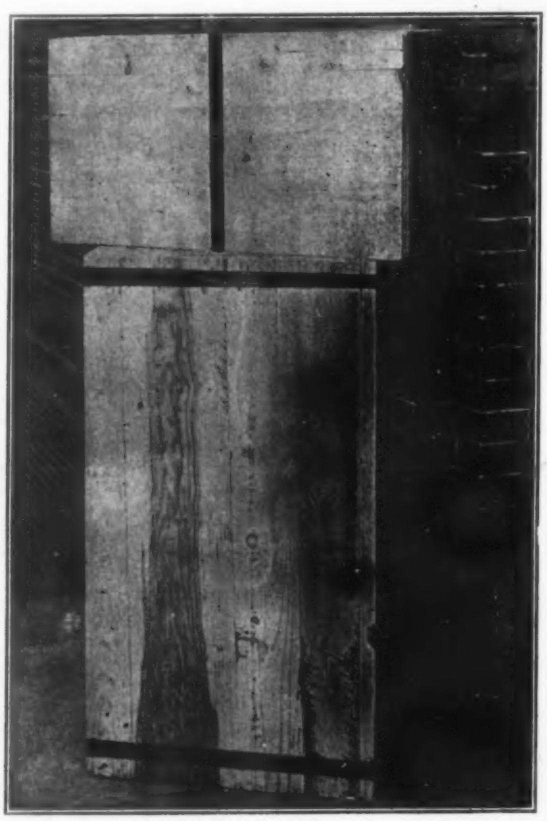
The government bulletin treats at length of the various methods of transportation, rail, water, rail and water, pack animals and man carriers and the style of packing demanded in each instance. It also considers the climatic conditions, port conditions, danger of pilfering, consular regulations, marking of shipments and difficulties arising from the use of second-hand containers, bearing old marks.

"In Ireland certain shipments of American cottonseed meal were received in bags which bore tags showing a guarantee below that called for in the contract. Evidently, the bags had been previously used for domestic shipments in America and when refilled the tags had not been removed. Although the meal held up in analysis to contract quality, the tags were a source of annoyance to the Irish importer, since many of his customers complained about them and he was obliged at much expense to have tested samples from each lot sold, to show his buyer that the meal ran higher in analysis than the tags indicated. No American cottonseed meal should be exported in bags that have been previously used for such shipments."

The packing of machinery, always an important and

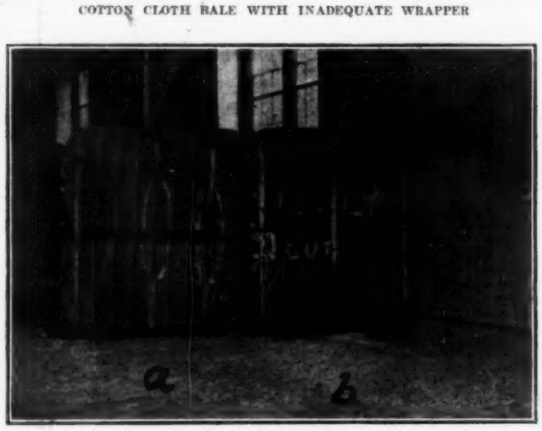
WELL-PACKED SHIPMENT OF PAPER

AMERICAN COTTON PROPERLY PACKED FOR EXPORT



SHIPPING CASES STRAPPED WITH STEEL BANDS

COTTON CLOTH BALE WITH INADEQUATE WRAPPER




CLOTH CUT BY STEEL BANDS

HOW EXPORTERS SHOULD PACK

frequently a difficult problem is discussed at length in a very comprehensive article prepared for an English journal by an engineer correspondent and transmitted by Consul Benjamin F. Chase, of Leeds.

The responsibility for poor packing is not always as easily determined as where the manufacturer exports directly, for if he ships through an export agent or commission house, one party may seek to shift the responsibility to the other. Along this line, Consul General William H. Michael of Calcutta (for many years Chief Clerk of the State Department at Washington) writes:

"The goods were packed poorly for foreign trade because the manufacturers packed at the factory for shipment to their export agents in New York or other ports, and the export agents, instead of repacking, simply forwarded the goods in the original cases. While the original cases were strong enough and entirely suitable for transportation from the factory to the shipping port, the packing was utterly unsuited to the long and severe strain of transit from point of shipment to India."

Frequently much expense can be saved for freighting by properly proportioning the packages. This is well illustrated by Commercial Agent W. A. Graham Clark of Honduras, who tells how a mule can carry 150 or 250 pounds according to the size of the package. He says:

"It should be noted that if a package weighs as much as 150 pounds a mule can carry only one, and as this rests on his backbone he cannot carry much above this weight, but he can carry two 125-pound packages, strapped one on each side."

The information from consuls includes reports from two consuls in Canada, three consuls in Mexico, one consul each in Central America, Costa Rica and Guatemala, two in Honduras and so on throughout the world.

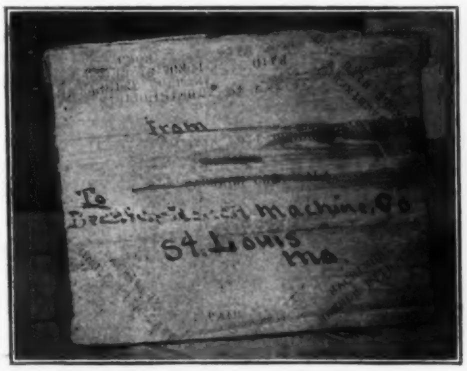
The definite character of the instructions is illustrated in the report by Consul William W. Canada of Vera Cruz, who says:

"Apparently the campaign inaugurated against faulty packing of merchandise coming from the United States has borne fruit, and its good effects are being seen in this port. Recently there arrived in Vera Cruz a shipment of 180 kegs of railroad spikes from Pittsburg, and of this entire lot only two kegs were in bad condition, though their contents were not lost. This shipment was put up in first-class order, as all kegs were hooped with iron and a piece of batten was fitted into the tops and bottoms, securely nailed, and then a piece of strap iron was nailed over these and down the sides of the package. . . .

"Many ice-cream freezers have been received recently at this port, and the methods of packing them should be changed to prevent damage. This class of merchandise should be crated in such a manner that there will be no projections outside the crate. The articles inside ought to be secure and immovable. All detachable parts, such as constitute movable mechanism, should be secured firmly by wiring. The crates, in addition to being well and strongly made, should be strapped and wired on the ends."

Consul General Thomas Ewing Dabney of San Salvador says:

"Local agents of typewriters have requested that machines be packed in double boxes—one box within the other—with straw between. This will avoid their breaking loose in the cases and being smashed by rough handling."




CASE BEARING TOO MANY MARKS

WELL-MADE BOX LINED WITH TIN AND CLOTH

Consul Philip E. Holland of Puerto Plata, Dominican Republic, says:

"Shippers of tallow should perforate the barrels and recork the holes to avoid leakage. By doing this heavy duty would be saved the importer, as watertight barrels pay a duty of $1.50 to $3 each, regardless of the fact that they are mere coverings."

Commercial Agent John M. Turner of Argentina and Paraguay says:

"It is preferable to mark packages on four sides, as then a mark will always be in sight. On delicate ware the word 'fragile' is suggested as being better than any other, as it means the same in a number of languages. Stencil marking is better than hand marking with a brush. Care should be taken that the mark is distinct before shipping, as packages rub together in a ship's hold and marks are liable to be erased or rendered indistinct."

Consul General Maxwell Blake of Colombia says:

"Hacienda proprietors in this country consult each other and manifest a great curiosity with reference to the delivery as to the successful operation of each other's new machinery purchased abroad. A reputation for unsafe packing is always sufficient to prevent the repetition of such an experience, however satisfactory a shipment might otherwise be."

As to the "This side up with care" sign so commonly used in this country, Consul General Frank H. Mason, writing from Paris, says:

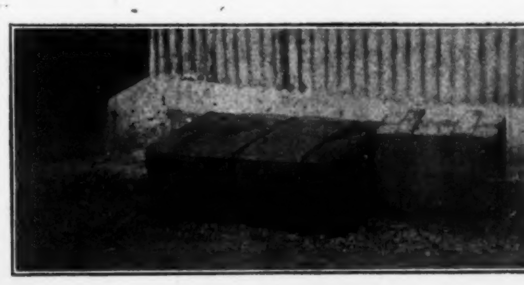
"The first general mistake of many American shippers is to pack machinery, furniture, automobiles, etc., so that the goods rest on the bottom of the case, and they are reasonably safe so long as the case is kept in an upright position. They mark the top of the case, "This side up," and take the chance that it will be kept so. But in unloading from cars, drays and lighters such cases are frequently rolled over and over. In the hold of the vessel they are packed so as to secure the greatest economy of space, resting on the side or end, or even bottom upward. At some European ports steam or electric cranes are used, which lift the goods out of the hold, swing them around, and land them more or less gently on the dock. At other places the merchandise has to be hoisted on the deck by the vessel's winch, and then slid down a long, steep slide to the dock, striking the bottom with a shock that frequently breaks packages and gives a serious shaking up to the contents."

In many of the reports from the consular officers in Europe, we find complaint as to the packing of cotton, and some point out errors in the packing of apples and other fresh fruits, dry fruits, lard, shoe blacking and other commodities of various kinds.

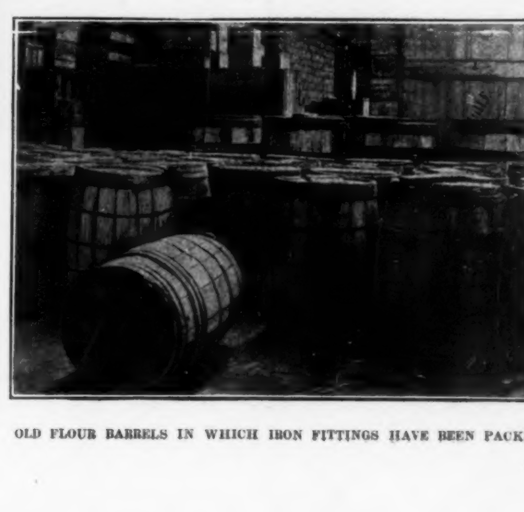
Consul Rufus Fleming of Edinburgh sends an extended report including specific directions for the shipment of a list of over 100 article, comprehending almost all kinds of merchandise and presenting the "Scotch idea of the requirements" of the trade with great particularity.

STOVE POORLY PACKED

BOLIVIAN INDIAN FREIGHT CARRIER



BOX AND BALE SHOWING EXCELLENT PACKING



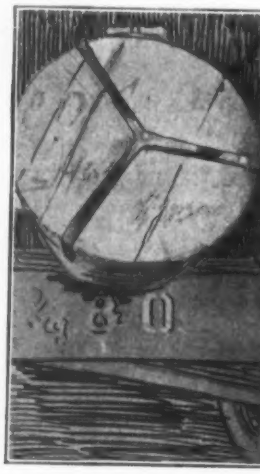
OLD FLOUR BARRELS IN WHICH IRON FITTINGS HAVE BEEN PACKED

HOW EXPORTERS SHOULD PACK

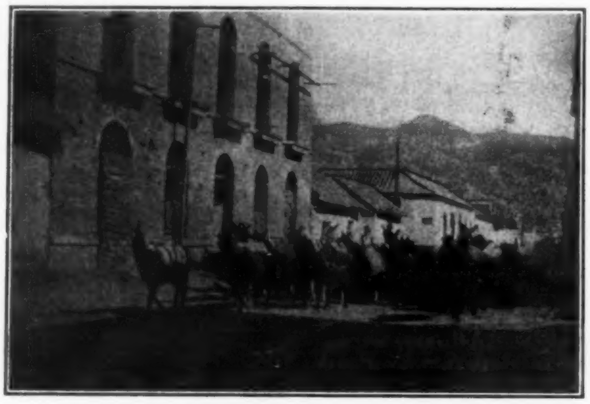
There is hardly a foreign point of the globe from Canada to South Africa, the Society Islands, Australia, India or Asiatic Turkey, that is not reported in the proposed publication.

The illustrations we have given are most interesting, and graphically present bad as well as good packing, some disastrous results of bad packing and sundry of the freight carriers met with in some of the corners of the world.

The Bolivian Indian freighter is of special interest. Commercial Agent W. A. Graham Clark of Bolivia says of him:



STRAPPED REINFORCED WOODEN PAIL

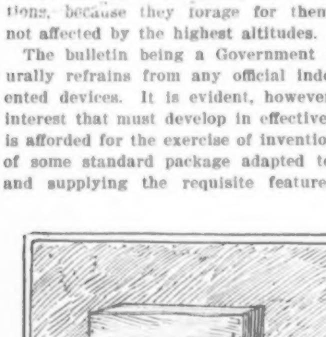


LLAMAS USED AS PACK ANIMALS

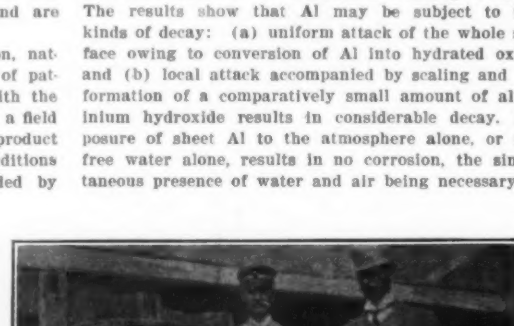
"The Indian himself can carry heavy loads. He always carries everything on his back, never on his head or in his hands. It is curious to see him loading. He kneels with his back to the load, throws around it two or three coils of a rope which he knots across his chest, and then, bending over on his face, he staggers to his feet and moves off with a load that two men can hardly lift from the ground with their hands."

Of the llamas shown in another illustration, it is said that while they are slow in their movements and weak, carrying only about 100 pounds each, they are prized as beasts of burden in the mountainous sections, because they forage for themselves, and are not affected by the highest altitudes.

The bulletin being a Government publication, naturally refrains from any official indorsement of patented devices. It is evident, however, that with the interest that must develop in effective packing, a field is afforded for the exercise of invention in the product of some standard package adapted to the conditions and supplying the requisite features demanded by many of the points, throughout the world, to which our products find their way.



SPOKES IN CRATE



BAR IRON PREPARED FOR TRANSPORTATION BY PACK ANIMALS

HOW EXPORTERS SHOULD PACK

### Gyroscopes for Stabilizing Aeroplanes

In a paper by Girardville in the *Comptes Rendus*, some valuable information is containea on the use of gyroscopes as a mean of balancing aeroplanes. The gyroscopes used weighed about five kilogrammes and rotated at 6,000 revolutions per minute. The gyrostatic action was used to cause rudders to work automatically. Experiments with a fixed apparatus were made in a uniform air current and also in variable winds at the top of the Eiffel Tower. It was found that the gyroscope with its pivoted frame tended to acquire an oscillatory movement; this was overcome by the use of damping planes immersed in water. This difficulty was not experienced when the apparatus was applied to gliders 12 square meters in area, the planes themselves being sufficient to damp the oscillations. This gyroscopic governor successfully compensated for disturbances of balance due to distribution of load and to variable winds, and was afterward used with advantage in a motor-driven aeroplane. Rotation was first obtained by means of flexible transmission and friction gearing; at present the driving power is obtained from a small fan exposed to the draught from the propeller.

### Corrosion of Aluminium

Messrs. E. Heyn and O. Bauer, of the Koenigl. Materialpruefungsamt, have made some investigations on the decay of aluminium. About fifty samples of Al in the form of sheet and various utensils have been tested in water and various solutions of salts, with a view to elucidating the cause of corrosion of, and the nature of the accompanying efflorescent growth on aluminium cooking utensils. The results show that Al may be subject to two kinds of decay: (a) uniform attack of the whole surface owing to conversion of Al into hydrated oxide, and (b) local attack accompanied by scaling and the formation of a comparatively small amount of aluminium hydroxide results in considerable decay. Exposure of sheet Al to the atmosphere alone, or airfree water alone, results in no corrosion, the simultaneous presence of water and air being necessary as is the case with iron. The hardness of the metal determines to a large extent the nature of the corrosion: soft Al is usually attacked uniformly, but hard-drawn Al blisters and exfoliates in lines agreeing with the direction of rolling, the pressing from a circular sheet resulting in these lines being straight on the bottom and curvilinear on the sides of a pressed cylindrical vessel. The harder the Al, the more liable it is to local attack, and annealing at 450 deg. C. entirely removes this tendency, the corrosion of annealed sheets being quite uniform. Distilled water and solutions of several salts such as sodium and calcium chloride produce uniform corrosion. The concentration of the salt solution has a great effect on the amount of action, in every case a certain definite concentration producing the most deleterious effect. The composition of the Al has little or no effect on the degree of corrosion. Greasing the vessels with vaseline decreased the tendency to corrode. To diminish the corrosion the authors propose that the Al should either be less severely cold-worked or that it should be subsequently annealed at 400 to 450 deg. C. to reduce its hardness, but at the same time point out that this reduces the mechanical strengh of the material.

### Building Materials and Noise

A German scientist named Nussbaum has for a long time been studying the question of the suppression of noise in dwelling houses. He has experimented both in the laboratory and in private houses. One point he has ascertained is that the more solid and tough and strong the building material is the more quickly and loudly it conveys sound, and its conductivity can best be tested by strokes with a piece of metal. The higher the tone the greater the conductivity.

Nussbaum has made many experiments with partition walls. He has found that those of tiles and cement transmit sound most and those of solid clay least. Between the two comes the wall of ordinary brick, and the more the brick is burned the more noise it transmits. A quickly hardening lime mortar is to be preferred to a clay mortar. One experiment showed that when a floor was covered with sand and cork mats spread over it hardly any noise penetrated to the room below, but that when the cork mats were joined together by any material underneath noises were at once perceptible.

To the question, How are the sounds of the piano or the violin in the neighboring apartments to be excluded? Nussbaum has returned the suggestion that the ceilings be treated as he successfully treated his telephone cell, namely, to line them with a layer of zinc or lead.

### New Zealand's Sulphur Island

One of the most extraordinary islands in the world lies in the Bay of Plenty, New Zealand. It is called White Island, and consists mainly of sulphur mixed with gypsum and a few other minerals. Over the island, which is about three miles in circumference and rises between 800 and 900 feet above the sea, there continually floats an immense cloud of vapor attaining an elevation of 10,000 feet.

In the center is a boiling lake of acid-charged water, covering fifty acres, and surrounded with blow holes from which steam and sulphurous fumes are emitted with great force and noise. With care a boat can be navigated on the lake. The sulphur from White Island is very pure, but little effort has yet been made to procure it systematically.

### The Alps Could Run the Railways

Engineers in Zurich report, after careful examination, that sufficient electric power could be developed from the waterfalls of the Alps to run all the railways of Switzerland. There would be little or no reduction of cost, it is said, but the time may come when the change from steam to electricity may be desirable, because Switzerland has to import all the coal she uses.

From twenty-one waterfalls, some of which are already partially utilized for industrial purposes, 86,000 horse-power could be developed, but only 60,000 horse-power would be required to replace the steam power now used on the railroads.

# Radiant Energy and Matter—I*

## Sir J. J. Thomson's Royal Institution Lectures

FOR his course of lectures at the Royal Institution this year Prof. Sir J. J. Thomson, of Cambridge, has selected the subject of "Radiant Energy and Matter."

In commencing his first lecture Sir J. J. Thomson said that he thought no apology was needed for his selection of a subject, since, as he was informed by Sir James Dewar, the last set, at the Royal Institution, on the subject of radiation, were delivered by Prof. Tyndall, and formed the basis of his book on "Radiant Heat and Light."

To every inhabitant of the solar system, whether of the earth or of Mars, the question, he continued, was one of vital importance. The planets did not live on their own resources of energy, but were dependent from day to day, almost from minute to minute, on the supplies received from the sun. The solar system, in short, was equivalent to a system of power distribution on an enormous scale. The power-house was the sun, and the method of distribution was practically one of wireless telegraphy, since there was every reason to believe that radiant energy traveled through the ether in a form mechanically equivalent to electric waves. The power expended in various ways on the earth was practically wholly received from the sun. Thus the energy available in coal was actually solar energy transformed into the energy of chemical separation. Water powers, again, were dependent on the raising of the water to a high level by heat received from the sun. The magnitude of the energy thus sent us from that body was far larger than most people realized. Actual measurement showed that shining in a clear sky the sun transmitted to the earth energy at the rate of 7,000 horse-power per acre.

At present this energy was practically all wasted, being expended for the most part merely in making the earth a little warmer than it otherwise would be, and this effect was most pronounced in regions where any addition to the temperature might well be dispensed with. If we knew how to harness this energy, we could obtain from it all the power necessary to run the works of the world. Various attempts had, indeed, been made to do this, and at the late meeting of the British Association at Sheffield, Mr. Fessenden had described an installation then in course of construction in one of the hotter States of the Union. In this instance it was proposed to use low-pressure steam-turbines, and it was claimed that the cost of the energy thus obtained would be less than half that of the cheapest hitherto available. However this might be, there was here, the speaker continued, a great resource for us to fall back upon when coal became scarce and dear, and the water powers available had all been taken up.

In the present course of lectures he proposed, he went on, to discuss the manner in which radiant energy was propagated, and how the intensity of radiation depended upon the temperature of the body from which it came. On this afternoon he would, he said, confine his discourse to questions concerning the total amount of energy coming out of a radiating body, at various temperatures, and would reserve for the next lecture questions as to the distribution of the energy in the spectrum, according to the color of the light. For the study of radiant energy it was necessary to have other means of measurement than the eye. [illegible]es gave out radiant energy at all temperatures [illegible] the absolute zero, but this energy did not [illegible] unless the temperature of the emitting [illegible] was 500 deg. F. to 600 deg. F. at least. Even then by far the larger proportion of the total energy existed in a form which did not affect the eye, and would not be perceived were no other means of detection avaliable. Even in the case of the sun three-fifths of the energy we received from this body produced no impression on the eye. Were, however, the temperature of the sun doubled, only about one-fifth of the total energy would escape perception as light, while, if the sun were still hotter, practically the whole of the energy would be received in a visible form. With the temperatures actually at our disposal we had means of investigation which would serve where optical methods were not available, and these almost all depended upon the conversion of radiant energy into heat.

The term "radiant heat" was sometimes used, but was rather a misnomer, since the energy in question did not become heat, as we now understood the term, till it fell upon, and was absorbed by, some body. It would be better, indeed, to call this "radiant heat" electricity, as there was every reason to believe that radiation was essentially an electrical phenomenon. In measuring the amount of radiant energy, the radiation was absorbed and transformed into heat.

A very delicate instrument for measuring heat radiation was the bolometer, which consisted simply of a strip of platinum, on which the radiation was allowed to fall, heating the strip and changing its resistance. Our means of measuring electrical resistance were, the speaker said, so delicate that temperature changes almost inconceivably small could thus be detected. With this instrument Langley had made his discoveries on the amount of heat the earth received from the sun. The bolometer was followed by the radiomicrometer of Prof. Boys. This consisted of a small thermopile (see Fig. 1), formed out of a rod of bismuth and another of antimony, suspended from a quartz fiber, as indicated. On heating the junction a current traversed the wires which completed the circuit. This circuit lay between the poles of a magnet, and the wires tended, when the current passed, to set themselves square with the lines of magnetic force. With this instrument it was possible to measure the radiation received from a candle a mile away. Even this instrument was, the speaker added, surpassed in delicacy by the radiometer of Prof. Nicols, which was an adaptation of the well-known radiometer of Crookes. With this instrument Prof. Nicols had been able to measure the heat received from the stars.

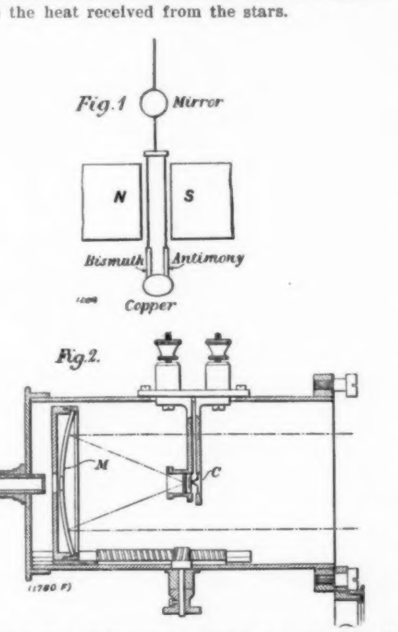



Fig. 1—Prof. Boys Radiometer, consisting of a small circuit suspended between the pole (N. S.) of a magnet and comprising a thermo-couple. Fig. 2.—The Féry Pyrometer. The rays of light and heat radiation enter the instrument along the dotted lines from the right, strike the mirror *M*, and are reflected to the focus at *C*, where they fall upon a thermopile. This is connected to a galvanometer the reflection of which indicates the temperature of the thermopile, and hence of the source. The eye-piece *E* is used for sighting the instrument on the source where temperature is to be measured.

For his experiment this afternoon, the lecturer proceeded, he would use a Féry pyrometer of the construction shown in section in Fig. 2. The radiant energy entered at the right, and, falling on the concave mirror *M*, was reflected on to a little thermopile at *C*. This was connected up to some form of current-measurer. In the industrial use of the instrument this was an ammeter graduated to give temperature readings direct. Though primarily intended for measuring furnace temperatures, the instrument could also be applied to measure the amount of radiation from much colder bodies; but then more delicate means of detecting the current generated were required, and he would himself therefore make use of a galvanometer suspended from the roof of the building, so as to be less liable to vibration.

Before making use of this instrument, however, he would, he proceeded, show another method of detecting radiation which did not affect the eye. This was due to the elder Becquerel, who found that if a phosphorescent body, such as zinc-blende, were rendered phosphorescent by exposure to a bright light, and then afterwards exposed to radiant energy of a different kind, the part exposed to certain descriptions of "black" light became almost as black as if painted with a brush. This observation could be used as the basis of a method of detecting radiant energy not perceptible by the eye. The range of radiation which produced the effect was not, however, very great, lying just a little on the infra-red side of the spectrum.

Exposing a plate covered with zinc-blende, and rendered phosphorescent, to the spectrum of an arc-lamp, the lecturer showed that the portion which caught the infra-red rays became quite black. Similarly, if a sheet of ebonite were placed between the phosphorescent sheet and the light of an arc-lamp, the rays which got through this opaque sheet again extinguished the phosphorescence, and a similar effect was shown to be produced by the radiation, which traversed a solution of iodine in bisulphide of carbon. Methods of detection based on these phenomena were, Sir Joseph continued, available with radiation of a certain kind, but for most purposes it was necessary to fall back on the methods already mentioned, in which the radiation was absorbed and transformed into heat.

A vital question, he proceeded, was the relation between the temperature of a body and the total amount of radiation given out by it. Newton thought that the amount of energy radiated from a body was proportional to the difference between the temperature of the body and that of its surroundings. This was true for small temperature differences, whatever the true law of radiation; but it did not give us much help when dealing with widely different temperatures. Applying Newton's law, Watson had estimated the temperature of the sun as 7,000,000 deg. C., which was about 1,000 times its proper value. The true law connecting radiation with temperature had been known for several years, and its discovery originated in some experiments by Tyndall, who measured the radiation from a piece of platinum at different temperatures. Thus, at 1,200 deg. C., he found that the amount of radiation was 11.7 times as much as at 525 deg. C. Taking these figures, Stefan tried to find a relation between the two absolute temperatures and the amount of the radiation emitted. In the first case the absolute temperature was 1,473 deg., and in the second 798 deg. F. Then Stefan found that the ratio $\left(\frac{1473}{798}\right)^4$ was about equal to 11.7, and this suggested to him that the energy of radiation from a body was proportional to the fourth power of the absolute temperature. Thus, if the absolute temperature were doubled, the energy radiated out would be 16 times as great.

This was, Prof. Thomson continued, perhaps the most important law as to radiant energy yet discovered, and it was known as the fourth-power law. Originally discovered by Stefan, as stated, it had been abundantly verified since, and it had further been found to have a strong basis in thermodynamics. A discussion of this he would, however, defer until he had, in a subsequent lecture, shown the existence of a pressure due to radiation, as this pressure was the basis on which Boltzmann and others had shown from thermodynamic considerations that the radiation must vary with the fourth power of the temperature.

The fourth-power law, the lecturer continued, had been extended, and physicists were able to say not merely the rate at which radiation varied with the temperature, but also the actual amount of energy emitted by a body at any temperature.

Thus, according to Kaulbars, the radiation emitted per second from 1 square centimenter of the surface of a blackened body was equal to $\sigma \theta^4$; where $\sigma = 5.52 \times 10^{-5}$ ergs, and $\theta$ denoted the absolute temperature.

If a body had a temperature of 1,000 degrees, therefore, it emitted from each square centimeter of its surface $5.5 \times 10^7$ ergs per second, or, in other words, gave out energy at the rate of about 1/200 horse-power per square centimeter. This radiation, moreover, came out from a very thin layer. Assuming this layer to be even as much as 1/100 millimeter thick, then a cubic centimeter of the surface of a body at 1000 degrees transformed energy at the rate of 5 horse-power. This, which was really an underestimate, well illustrated, the speaker said, the compactness of the mechanism by which heat was transformed into radiation. Since the amount of energy coming out was so large, it was easy to understand the rapid extinction of light from small particles, such as sparks.

One very interesting application of the equation just given was, he said, to the determination of the temperature of the sun. Though somewhat difficult, owing to the effects of atmospheric absorption, it was possible to measure the intensity of the radiation received from each square centimeter of the sun's surface, and from this to deduce the temperature of the latter. The most accurate results appeared to make this about 6,000 degrees absolute, which was much lower than was at one time thought. At 6,000 degrees absolute the rate at which energy was radiated per square foot of surface was formidable, being about 15,000 horse-power. How,

* The report here given of Sir J. J. Thomson's lecture is taken from *Engineering*.

then, did the sun keep on radiating at this rate without getting appreciably colder? Nowadays we always tried to see if radioactivity would not suffice in such cases. In the case of the sun the energy could not be supplied by radium, as the life of the latter was too short, being quite insignificant compared with geological time. In this respect uranium, being very much longer lived, fitted in all right, but it remained to be seen whether the possession of a good supply of uranium would be enough to supply energy at the rate required. Unfortunately, on making the calculation, it turned out that even if the sun consisted wholly of uranium the rate of energy supply would still be insufficient. The sun's surface radiated energy at the rate of $1.2 \times 10^{11}$ ergs per second, while uranium liberated energy at the rate of 1 erg per second per gramme. Hence the number of grammes of uranium below each square centimeter of the sun's surface would need to be $1.2 \times 10^{11}$, and the whole mass below 1 square centimeter of the sun's surface was actually nothing like as great. Hence it was necessary to give up radioactivity as a sufficient source of the sun's energy, and in consequence almost the only hypothesis at present tenable was that at first put forward by Helmholtz. An influx of meteors into the sun had been suggested by some as the source of the solar energy. The objection to this was that in that case the earth must act, to a certain extent, as an umbrella, and calculation showed that, if it received a corresponding proportion of the assumed meteoric shower, the number received would be enough to make the earth red hot. Helmholtz had, in consequence, suggested that the energy was supplied by the sun's attraction on itself. This hypothesis implied that the sun was shrinking at the rate of about 200 feet per year, and with existing means of measurement there was at present nothing to be said against this conclusion.

(To be continued.)

# Carbureters and Vaporizers*

## How They Should be Designed

By T. A. Borthwick

An analysis at all approaching completeness of even one-tenth of the carbureters for vaporizing gasoline or kerosene that are now being manufactured, either as belonging to a definite machine or being placed on the market as an accessory, would be a work extending to several volumes. The scope of this field may be gaged by a glance at the patents review of the technical journals, where two or three specifications of newly patented designs may be found almost every week. It is, therefore, not intended here to deal with them fully as regards their mechanical arrangement, but to consider the conditions most favorable for the economical and satisfactory production of a combustible fuel, and to trace its path from the entry into the float chamber until it reaches the combustion chamber.

It may be taken primarily that the use of a jet, of which the effective level is regulated by a float chamber, as originated by Maybath, is almost universally adopted in all cases in which gasoline is the fuel. This type is also used to a very large extent in engines using refined and semi-refined kerosene. It is with devices of this kind that this article will deal.

It is a matter for surprise that the use of such a delicate and uncertain piece of apparatus has not been avoided. In fact, the float chamber has received very little attention beyond the arrangement of the balance weights, or in attempts to dispense with them altogether.

The arrangements shown in Figs. 1, 2 and 3 are those most commonly adopted in current practice. Fig. 1 is arranged so as to admit the lightest possible working parts and thus minimize the troubles due to inertia when traveling over uneven roads; it has the further merit that any surplus of gasoline escaping on account of vibrations of the needle valve causes the float to press more heavily on the balance weight, and thus to close the valve more tightly on its seat.

The arrangement shown in Fig. 2 requires the needle and its fittings to be somewhat heavier than in Fig. 1, since the pressure due to the weight alone acts to keep the valve on its seat. The design shown in Fig. 3 has the merit of simplicity, and has also the same advantages as Fig. 1; but it is open to the objection that the gasoline pipe has to be uncoupled every time the float chamber is opened, an occurrence which happens not infrequently, especially with kerosene.

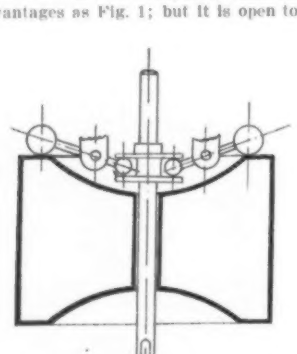


Fig. 1.—DIRECT NEEDLE VALVE

Among improvements relating to the float chamber that known as the Gillet-Schwarz device is one of the more important. This consists of a through connection between the mixture pipe and the space above the fuel pipe in the float chamber by means of a branch pipe to which is attached a cock, making the effective area of the through connection adjustable. The resultant effect of this device is to tend to produce a constant ratio between the pressure in the float chamber and that over the jet, or, in other words, to produce a constant effective height for the jet, and, therefore, on the wider opening of the throttle, to give a weaker mixture. It may, perhaps, be satisfactory to explain the desirability of this weakening of the mixture with the opening of the throttle by reminding the reader that, with a partially closed throttle, the cylinder is only parially filled; consequently, the compression pressure is lowered, and a richer mixture is required to enable it to be ignited. The best pressure ratio is obtained experimentally by opening or closing the cock in the by-pass, as may be required. Another, and perhaps more valuable, quality in the Gillet-Schwarz device is, that in multi-cylinder engines it discriminates between the supplies of mixture to each cylinder; e. g., in four, and more particularly in six-cylinder engines, it will frequently be found that the mixtures are required of different strengths for the different cylinders, as shown by the fact that some of the cylinders will fire weakly or miss altogether, while the remainder will fire well. This is partially due to variations in the volumes of the combustion chambers, but more largely because of leaking past valves and valve covers, and perhaps it is also due to a still larger extent to the timing of the valves not being uniform throughout the cylinders. This device assists in partially neutralizing the last two faults, since the effective height of the jet being approximately constant, the cylinder with the stronger suction will draw the moist air, and as it will have nearly a uniformly higher compression, the ignition of the charge is assured. On the other hand, the cylinder with the weaker suction, and consequently weaker compression, will draw less air, thus forming a richer and more readily fired mixture.

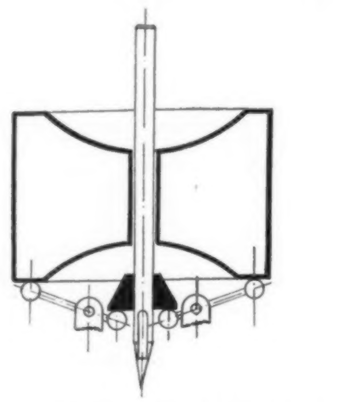


Fig. 2.—INVERTED NEEDLE VALVE

After mentioning the above device, we may add that the same principle has been utilized in a carbureter brought out by Messrs. Cravens, Ltd., of Sheffield.

Little else need be said with regard to the float chamber except, perhaps, a note about the position of the hole between the float chamber and the jet. One frequently finds that this is situated at the bottom of the chamber, where it draws any grit or sediment which may find its way inward. The hole should be at least a quarter of an inch from the bottom, or preferably more, since even if a gasoline filter is provided, one finds that dirt still finds its way in by some mysterious means. It must also be remembered that it is not safe to assume that adequate precautions are taken to exclude all dirt when the gasoline pipe is uncoupled or when the float chamber cover is removed.

A final item to be noted is the needle valve. It is frequently found that this is made of mild steel, and, therefore, exceedingly liable to become rusted in the presence of gasoline; it should, therefore, be made of a high-percentage nickel steel, or of silver steel.

Before dealing with the details of the mixed chamber it is desirable to consider the general disposition of the mechanism of the carbureter. For purposes of comparison, we may divide all carbureters into two classes—vertical and horizontal. Referring to the former class, it may be noted that the vertical carbureter usually gives a more direct flow for the gases, has fewer bends, is more economical in fuel consumption than the horizontal type, and is, furthermore, not so liable to become choked. As an offset to these good qualities the horizontal carbureter is undoubtedly easier to be started, since the incoming air rushes directly across the top of the jet instead of flowing along it.

We will now consider some of the very simplest forms of carbureters, being those without any kind of automatic controlling device for the auxiliary air inlet, and hence without any means of discrimination between requirements of a full throttle at low speeds and the same at high speeds. This class of carbureters is by no means the largest; but, speaking generally, they give singularly satisfactory results, very nearly equaling those attained by carbureters provided with the most accurate adjustments. Under these circumstances one is almost inclined to wonder whether, for practical purposes, the extra complications and delicate parts of the more refined devices are warranted.

Taking a few typical examples of this class, we will first examine the White & Poppe carbureter, which is well to the fore in its line. The general arrangement is shown diagrammatically in Fig. 4, from which it will be seen that a vertical rotary throttle is placed in the path of the inlet gases and that the throttle casting forms a shroud over the jet, a gasoline-tight joint being formed between it and the conical top of the jet and the shroud being kept on its seating by means of the spring *A*. The hole in the jet and the shroud is disposed eccentrically in such a way that the jet, the air inlet and the mixture outlet are all cut off simultaneously and in a definite, predetermined proportion. A simpler and more satisfactory way of effecting this three-fold function could hardly be imagined. The only adjustment of any kind is that for the air outlet, by means of the sleeve interposed between the throttle and the casing. This is operated by moving two stops on the chamber cover,

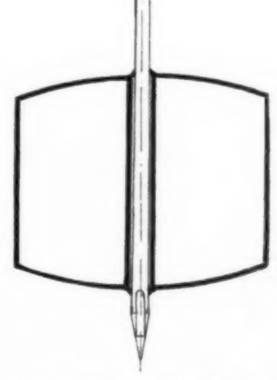


Fig. 3.—FLOAT AND NEEDLE VALVE

* Reprinted from *Cassier's Magazine*.

and compensates for varying atmospheric conditions, and also for different qualities of gasoline.

The remaining portion of the White & Poppe carbureter is a short trunk placed between the mixture outlet and the engine inlet pipe; it serves the purpose of removing any heavy particles of gasoline, therefore making the mixture more homogeneous. We believe, however, that this atomizing chamber has been omitted in the latest designs of this carbureter.

An approximately similar carbureter, but of the vertical type, is the Claudel-Holson, which, however, has a different kind of jet, and one which is both ingenious and interesting. Referring to Fig. 5, the hairline circle represents the throttle, and it will be seen that the jet outlet, and also the holes in the sleeve surrounding the jet, are inclosed by the throttle, while the holes at the bottom of the sleeve are outside the jet. The function of the sleeve may be explained as follows: Assuming a partially closed throttle, the holes at the top of the sleeve will be in a partial vacuum, caused by the suction of the engine, while the holes at the bottom will be approximately at atmospheric pressure. A current of air will, therefore, pass upward inside the sleeve and draw upon the jet. If, however, the throttle were fully open, the top holes would be nearer atmospheric pressure, and the pressure difference between the top and bottom holes would be less, and, therefore, there would be less suction on the jet from this source.

By these means the requirements of proportionately richer mixtures for the tighter throttles are effectively and simply met. It may be added that the Claudel-Holson is an exceedingly well constructed and designed carbureter, affording a specially smooth and straight forward flow for the gases.

Another example of this type of carbureter is one which has been fitted on the Belsize cars. It is of the vertical type, and is so arranged that a throat of constant size is maintained, but that, simultaneously with the rotation of the throttle, a screw of quick pitch is also rotated, and by its means a sleeve is lifted in a circular chamber, coned inward, and therefore the effective air-inlet is increased, and the mixture is atomized higher up in the carbureter, prior to reaching the throttle. Further examples of this type of carbureter are the Trier & Martin triple jet, the Craven, already mentioned under the heading of float chamber, and the H. P. carbureter. This last has a simple means by which, if desired, air only may be drawn into the engine, after the complete closing of the throttle.

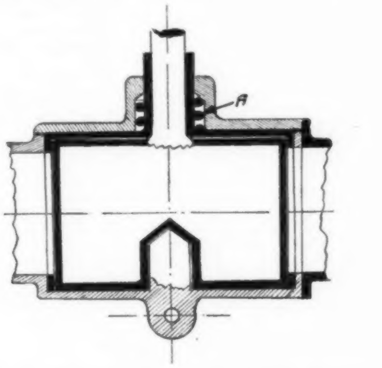



FIG. 4.—WHITE AND POPPE CARBURETER

As regards the jet, it may be mentioned that it should be kept as large as possible, in order to lessen the disturbing and fluctuating influence of friction. Since, however, for slow running, with no load, the quantity required is almost infinitesimal, the idea of providing a separate jet or a variable jet to serve this purpose may be worthy of consideration. The former method, of a separate jet, is probably the better one of the two, unless some method is adopted similar to that used in the White & Poppe carbureter, in which the jet is cut off eccentrically. The earlier method adopted by a number of makers, of lowering a taper needle into the jet, is not nearly so good, since capillary attraction and jet friction combine to make the supply very variable. It should be emphasized, however, that the secondary jet is to be used solely for the purpose stated, and should be neutralized, or, preferably, cut off positively for working positions under load.

It may be recalled that a year or two ago several triple and quadruple jet carbureters were brought out, but these have, for the most part, since been abandoned. These would obviously have an abnormal amount of jet friction and, therefore, be sluggish in action. For reasons already stated, they would not give uniform results, as the friction, even under uniform atmospheric conditions, does not remain a constant quantity.

A form of jet, as fitted to the Itala and other vertical carbureters, may here be mentioned; it is shown in Fig. 6. It will be seen that the gasoline is compelled to leave the jet head radially; the object is to integrate it with the incoming air, but it is somewhat questionable whether it penetrates any further into the stream of air than that which immediately surrounds the jet.

In considering the subject of the throat of a carbureter, several features should be taken into account.

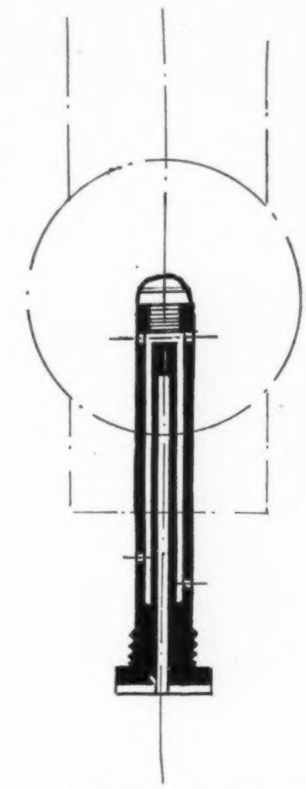


FIG. 5.—CLAUDEL-HOLSON CARBURETER

So far as the surfaces are concerned, one has only to compare the action of a rough and a machined throat of similar dimensions to appreciate the influence of the nature of surface upon performance. We may also add that we have found engines to run appreciably better with inlet pipes made of solid-drawn copper tubing than when made of castings of similar shape and size.

When a carbureter for gasoline is fitted with a throat of constant diameter, it will be found that the most satisfactory size is that which gives the air a velocity of about 100 feet per second for a horizontal throat, or 120 feet per second for a vertical throat.

Taking, as an example, an engine of four inches bore and five inches stroke, and capable of being throttled down to 160 revolutions per minute, the carbureters, assuming the cylinders to be properly filled, should have a throat area of 0.358 square inch, corresponding to about 11/16 inch diameter, when of the horizontal pattern, and 0.298 square inch, or ⅝ inch diameter, if of the vertical pattern.

It is, however, more than probable that when the engine is idly rotating at that speed, the throttle aperture does not allow the cylinders to become more than one-third full. To cover this condition, and also to get the best mean for general working, it is advisable to fit a cut-off for the throat, although this is not generally provided. On the White & Poppe carbureter, the throat is mechanically enlarged, and it is found that an engine of the size given above will run very light, when in good condition, at 160 revolutions per minute, with an effective throat-area equivalent to a diameter of 3/16 of an inch.

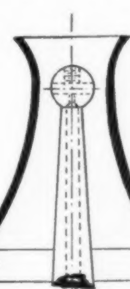


FIG. 6.—ITALA CARBURETER

This throat reduction is done in a very ingenious manner in the Trier & Martin carbureter. In the earlier patterns a vertical shutter was hung across the throat, and cut off all but a small portion until the suction of the engine became powerful enough to lift it out of the way. More recently the same makers have used a device shown in Fig. 7, which is self-explanatory; the suction of the engine pulls the spring, and allows additional air to pass between the coils. A similar spring device has been used to operate an auxiliary air inlet.

In many carbureters of the horizontal pattern, there is no reason why a much greater application of the *vena contracta* should not be made, and the throat enlarged accordingly. Taking the case which we have already considered, that is, a throat 11/16 inch diameter, and also take the *vena contracta* constant as 0.6, we might enlarge the throat to 0.37: 0.6 square inch, or 0.601 square inch, or ⅞ inch diameter, and place the jet where the contradiction occurs. This plan could, of course, be quite logically adopted with vertical carbureters, but the application of it would present some difficulties in the arrangement of the parts.

Regarding the use of other spirits than gasoline, it may be mentioned that benzol, methlylated spirits, and also benzine, may all be used without alteration to the gasoline carbureter, other than the change in the size of the jet. Benzine is somewhat slow and heavy in its working, but methylated spirit gives an exceedingly lively engine and also very good results from the point of view of power output; but it also makes an engine which is somewhat too "hard" in working for general use.

The use of fuels of the kerosene type, such as the American White Rose, or Royal Daylight, the Russian Russolene, Scottish Lighthouse, Burma Victoria, or refined Borneo, and the numerous other oils of approximately the same nature, also the heavier and more sluggish spirits, such as the usual commercial grades of naphtha, presents no very great difficulties, after the few necessary modifications have been made in the design of the carbureter.

FIG. 7.—TRIER AND MARTIN NOZZLE

It is necessary, primarily, to provide a vaporizer which may be heated by the exhaust gases of the engine, or by other means, such as a blowlamp. This vaporizer should be so designed that as large a surface as possible is presented to the incoming mixture, in order to prevent the formation of a core of unvaporized mixture; this latter condition being apt to occur if tubes of at all large diameter are used.

The method of drawing in the air is different from that used with the gasoline carbureter. With the carbureter for kerosene, the amount of air passing through the throat must be only sufficient to lift the oil out of the jet and carry it onward, so that the unvaporized mixture is not sufficiently rich in oxygen to become ignited in the vaporizer.

The additional air required to form the explosive mixture is taken in by means of a separate valve between the vaporizer and the engine inlet valve. There are a few carbureters for kerosene on the market as a specialty, the majority being the exclusive designs adapted to and confined to the engines of the makers.

### Wireless Railroad Signals

FOR some time past the Prussian and Bavarian authorities have been experimenting with a system of wireless telegraph signals for railroads which is said to promise good results. An aerial transmitter wire is carried on the telegraph poles at the side of the road with transmitting stations in the signal bell towers, and a wire loop antenna is placed on the top of one of the cars of the train. By this means signal to "stop," "go ahead," "go slow," and so on, can be transmitted to moving trains over an effective range of 12 kilometers, nearly 7½ miles. The average distance between the bell towers on German railroads is only 18 kilometers, so that the range of the signals is amply sufficient.

**Dressing for Hunting Boots.**—Seven hundred parts of yellow vaseline oil, 50 parts of olive oil, 250 parts of yellow ceresine, 1 part anchusine, 10 drops oil of mirbane, 5 drops of East Indian balm oil.

# The Lost Arts of Chemistry*

## The Origin and Reason for Some Widespread Beliefs

By W. D. Richardson

In addition to chronicling past and present events merely, it pleases the historian from time to time to ascertain, as nearly as he can, by a comparison of present with past conditions and present knowledge and practise with past knowledge and practise, the present condition of mankind of any particular society, in comparison with past conditions. Thus are compared present systems of government with past systems, new religious beliefs with old, modern science with ancient science, present-day arts and manufactures with those of old.

Progress never takes a straight course for any considerable length of time. Nor does it even follow an undulating course in one general direction. But there are advancements and retrogressions, repeated endlessly. And again, progress as recorded by history does not represent necessarily the progress of the whole human race. On the contrary, it does not represent even a large part of the human race, but at most an isolated portion of it, and in this isolated portion the progress is recorded not of the whole but of the most advanced individuals only. When we say that the present age is one of great business, scientific and manufacturing or artistic achievements in comparison with the fourteenth century, for example, we mean that a few individuals, very few in fact compared with the total number, have contrived to bring about great results in those fields of human activity. But we must remember at the same time that the majority of individuals may not have been directly concerned in the advance or may not have contributed directly to it at all. Indeed, it seems as though the lowest members of the human race to-day are no farther advanced mentally than were their progenitors in recent geologic times. Even with rapid progress of the most favored or most enterprising individuals there may be little progress or none in the case of the average of mankind. It is not unlikely that at the present day the intellectual gap between the mentally highest and lowest of mankind is greater than at any previous time.

In spite of the high intellectual and practical standard reached by the leading men of to-day, from another point of view (called by some the pessimistic) the outlook to-day is far from satisfactory in politics, religion, manufacture or science. Whether we consider our all but failing efforts at democracy in the United States or the vacillating and undirected religious tendencies of the people (as shown by Mormonism, Seventh Day Adventism, Dowieism, Christian Science, the old theologies or the strange oriental doctrines and ideals of the majority of our people, which fortunately are scarcely put into practise); or if we consider the slow conservatism and plodding course of manufacture and business, including our great untouched problem of the economic distribution of goods, we can not fail to be impressed with the length of the journey which we must sooner or later take, on the road of development.

But we may turn from the rather unsatisfactory consideration of politics, religion and business to the consideration of modern science with a rare degree of satisfaction and enthusiasm. There, at least, progress is visible, tangible or even obtrusive. There, at least, the forward movement does not take the slow, conservative, timid pace of business, nor follow the meandering, uncertain, sentimental path of religion, or the crude meaningless way of politics. In that field at least the way is certain, the methods positive, the results satisfying, the application secure and the progress lively. Considered by itself, science and the scientific method are the most satisfactory and satisfying things in the possession of the human mind. The unfortunate thing—it can not be classed as a criticism—about science is that it has left the multitude untouched. With the results of science and the scientific method on every hand forming so large a part of our splendid materialistic civilization, nevertheless the great, the overwhelming majority of people are ignorant of the methods, the aims and the results of scientific inquiry in daily use, and of daily necessity. Of even greater import, the scientific method of thought is not a part of their mental equipment.

Science and the scientific method have their critics, no less than other excellent things. Science is unmoral, cold, heartless, pessimistic, hopeless, often cruel in method, say they. The scientific inquirer can well afford to let most of such accusations as these go unchallenged. But there is one statement which has been sown broadcast, which springs up in a thousand unexpected places, and which it is worth while to devote some attention to in order to refute it. It is the statement that ancient peoples have been possessed of knowledge and of arts unknown to modern times; and indeed, people would have us believe that this knowledge and these arts are recoverable by us if at all only with extreme difficulty. The "lost arts" is the cry. In so far as these so-called lost arts concern applied chemistry let us examine into them, and ascertain if possible whether or not there is truth in the assertions alluded to.

In the first place we may well inquire into the origin of the widespread belief that the knowledge of various mechanical and chemical arts has been lost to mankind. Probably first among the causes is that universal veneration of antiquity which makes gods and saints out of heroes and martyrs of the past, leads to ancestor worship and in general exaggerates the virtues, the crafts and the deeds of valor of olden times. Secondly, the delight of many persons in mystery, their tendency toward belief in the mysterious, occult and miraculous, against their better judgment and the facts in the case, have great influence in originating and perpetuating the belief in lost arts. Thirdly, among the more general causes, we may place vague statements or sentences which we cannot accurately translate in ancient manuscripts. Fourthly, the natural reaction against an egotistical age. Fifthly, the use by ancient peoples for certain purposes of materials which we would not use to-day on account of their unsuitability. This leads to the conclusion that the ancients knew of different and better methods of preparing the material. Sixth, it has pleased certain writers and lecturers to insist strongly upon the point that there have been at various times in existence arts no longer known and used. One finds brief statements in various books of such import as "they knew how to harden copper." "Their mortar outlasted the stone it cemented." "The degree of perfection they reached in enameling has never since been attained," etc. In America the man who has had probably more effect than others in this respect was Wendell Phillips. His lecture entitled "The Lost Arts" was first delivered in the American Lyceum course in the winter of 1838. During succeeding years the lecture was repeated about 2,000 times, and was heard by all sorts of audiences throughout the country, and at the time and subsequently made a great impression. Many persons now living still remember the famous lecture. It is difficult to read this lecture to-day and believe that it was seriously intended in certain places by Wendell Phillips; yet I am assured by several individuals who heard it that, although illumined by humor in places, it was, as a whole, seriously intended and received. In various lectures Phillips committed many sins against accuracy and truth, but in none more than in the "Lost Arts." He misquoted Pliny in regard to his statements about the origin of glass manufacture—a tale familiar to you all and hardly rising to the dignity of a first-class fable. And of all authors, Pliny can least afford to be misquoted, being already overburdened with inaccuracy and unreliability. Let me present a few brief quotations from this remarkable lecture:

"The chemistry of the most ancient period had reached a point which we have never even approached, and which we in vain struggle to reach to-day. Indeed, the whole management of the effect of light on glass is still a matter of profound study.

"The second story of half a dozen—certainly five—related to the age of Tiberius, the time of Saint Paul, and tells of a Roman who had been banished, and who returned to Rome, bringing a wonderful cup. This cup he dashed upon the marble pavement, and it was crushed, not broken, by the fall. It was dented some, and with a hammer he easily brought it into shape again. It was brilliant, transparent, but not brittle. I had a wineglass when I made this talk in New Haven; and among the audience was the owner, Prof. Silliman. He was kind enough to come to the platform when I had ended, and say that he was familiar with most of my facts; but speaking of malleable glass, he had this to say—that it was nearly a natural impossibility, and that no amount of evidence which could be brought would make him credit it. Well, the Romans got their chemistry from the Arabians; they brought it into Spain eight centuries ago, and in their books of that age they claim that they got from the Arabians malleable glass. There is a kind of glass spoken of there that, if supported by one end, by its own weight in twenty hours would dwindle down to a fine line, and that you could curve it around your wrist.

"Cicero said that he had seen the entire 'Iliad,' which is a poem as large as the New Testament, written on a skin so that it could be rolled up in the compass of a nut-shell. Now, this is imperceptible to the ordinary eye. You have seen the Declaration of Independence in the compass of a quarter of a dollar, written with glasses. I have to-day a paper at home, as long as half my hand, on which was photographed the whole contents of a London newspaper. It was put under a dove's wing and sent into Paris, where they enlarged it and read the news. This copy of the "Iliad" must have been made by some such process.

"Pliny says that Nero the tyrant had a ring with a gem in it, which he looked through, and watched the sword play of the gladiators—men who killed each other to amuse the people—more clearly than with the naked eye. So Nero had an opera-glass.

"So Mauritius the Sicilian stood on the promontory of his island and could sweep over the entire sea to the coast of Africa with his nauscopite, which is a word derived from two Greek words, meaning 'to see a ship.' Evidently Mauritius, who was a pirate, had a marine telescope.

"The French who went to Egypt with Napoleon said that all the colors were perfect except the greenish-white, which is the hardest for us. They had no difficulty with the Tyrian blue. The burned city of Pompeii was a city of stucco. All the houses are stucco outside, and it is stained with Tyrian blue, the royal color of antiquity.

"But you never can rely on the name of a color after a thousand years. So the Tyrian blue is almost a red—about the color of these curtains. This is a city all of red. It had been buried seventeen hundred years; and if you take a shovel now, and clear away the ashes, this color flames up upon you, a great deal richer than anything we can produce."

I feel reasonably sure from what I know of the history of science that the main points made in this lecture were not true in Wendell Phillips's time. I know they are not true to-day.

To recapitulate: The causes of a belief in lost arts appear to be the veneration of antiquity, the belief in the mysterious and occult, inaccuracies in and inaccurate readings of ancient texts, reaction against present-day egotism, the use of unsuitable materials by ancient peoples and the emphasis laid upon ancient skill by half-accurate writers.

No one could wish to detract from the great, the skilful and the beautiful works of the ancients. All we can desire is a proper and clear understanding of their accomplishments.

Long before the way was prepared for an approach to chemistry as a science, many were the chemical facts known and used, and many the chemical arts and manufactures which arose and flourished. The foundations of many of our greatest chemical industries were securely laid long before the science of chemistry lent its aid. The industries of cement and plaster, glass, ceramics, pigments, oils and fats, varnishes and lacquers, sugar, fermentation, textiles, paper, dyeing, leather, glue and various metallurgical industries are some of those which were very well developed before the advent of scientific chemistry. Indeed, the science of chemistry has found and still finds some of its richest materials in these very industries. What can be accomplished by patient manual skill and dexterity is amazing, and it must be conceded that the adoption of exact mechanical processes in our times has lessened the necessity for such skill in many directions. It is true also that many ancient peoples and many of the less mechanical modern ones have applied manual dexterity to their arts in such a way that we marvel at the results. But it is difficult to find a case where similar application to-day would not yield a similar result. Nothing can be considered lost unless it be the demand for and desire to produce works of a certain kind.

Again, it is true that some arts and modes of manufacture reach a stage which we may call practical perfection, relatively soon after the initial discoveries are made which give them their first impetus. After this point is reached the improvements are few or none (and if any occur, they come from an outside source, as the application of power to the loom). Examples are abundant; the hoe and other simple farming implements; the safety bicycle; the sewing machine; the aeroplane. It must, of course, be presup-

* An address delivered before the Minneapolis meeting of the American Chemical Society.

posed that suitable materials for manufacture have been previously discovered and are at hand, or can be quickly adapted. In such cases as these the opportunities of later generations to develop and improve are meager; but the limitation is not of the inventors, but of the things themselves.

For many years the great pyramid of Egypt was held up to the youth in all lands as an example of what had been accomplished by ancient peoples and which could not be duplicated to-day. It was held, in fact, that the ancient Egyptians were possessed of mechanical knowledge and appliances unknown to us. We must all concede that the great pyramid is a remarkable, if useless, piece of architecture, laid out with extreme precision and carried to its completion in a masterly way. But it turns out that the Egyptians of the Old Kingdom possesed rather limited knowledge of mechanics, not having even developed the movable pulley. The great pyramid was built by man-power multiplied many thousand times. Finally, can it be considered a greater work than a great railway system or battleship?

That arts have been temporarily lost at least for practical purposes is true. The history of industry has not yet been written—possibly it is too great a task—and adequate data have not been collected, and hence are not available, but it seems true from the information available that there has been a remarkable continuity in industrial processes in spite of many adverse circumstances.

War is probably the greatest cause of breaks in the continuity of manufacturing processes and the arts of peace, and if we are to believe past records, the domination of theological systems or religious dogmatism has been and is the most effective influence in restraining the development of scientific methods of inquiry and consequently progress in the arts. On the other hand, commerce and the migrations of peoples have been effective in spreading industries. War destroys commerce, but often causes migrations, and hence has been an active influence in the spreading of industry as well as in checking it. War has also imposed new civilizations on old, and thus caused an unnatural intercourse between two civilizations, which would naturally result in the extension of knowledge of the industries peculiar to each.

Let us examine for a few moments some of the arts claimed to be now lost. The knowledge of a process for hardening copper is commonly ascribed to many ancient and prehistoric peoples, and is devoutly believed in by many persons. Now, in the first place, if this knowledge was formerly possessed we have no direct evidence of it, for the copper implements which have come down to us are no harder than those we might make ourselves to-day. A metal may be hardened in two ways: By physical treatment or by alloying it with other metals or substances. Copper may be hardened to some extent by hammering, in the same way that many other metals may be hardened. The common alloys, bronze and brass, are harder than the pure metal. It is probable that ancient peoples used the process of hammering to harden copper, and it is certain that they made use of the alloys of copper first with tin and later with zinc, for many purposes, including tools and implements. But because copper and copper alloys were used for implements subjected to rough usage, this does not justify us in concluding that the makers had knowledge of a method for making the metal hard, durable and serviceable. The simple and direct explanation is that they had no better material for the purpose at their command, just as in the bone and stone periods bone and stone were the best materials of construction available for tools and implements. There is no justification for the idea that ancient peoples knew how to harden copper by means unknown to metallurgists of the present day.

The ceramic arts are among the oldest known to mankind, and the earliest development of them will probably remain unknown to us. They had their beginnings in the bone and stone age, and were probably first practised by women, not by men. The first clay vessels may have been clay-covered baskets dried in the sun—we do not know certainly. From those early beginnings to the highest types of the art required the labor of many potters, numberless experiments and numberless failures. We class ceramics among the chemical industries, and properly so; and yet the ceramic art originated, developed and flourished in many ages and in many parts of the earth without any thought of or aid from the science of chemistry. It has always been and still is to a very large extent an empirical industry. The essential difference between the pottery practice of ancient times and the most scientific practice of modern times lies in the reproducibility of bodies and glazes by modern methods. And yet few chemists in the industry have the temerity to predict how a new clay or glaze will come out of the kiln. The potters of long ago, by countless trials of different materials and countless failures, were able to produce certain effects; and they were able to continue the manufacture of similar wares and produce similar effects so long as they were able to obtain materials from the same sources. A change of material would almost certainly mean a change in product. It must not be forgotten that this same limitation affects the ceramic industry to-day to a very large extent. The varieties and properties of clays are almost numberless. It is true that potters of all times have been able to devise certain simple tests whereby they have been able to recognize differences and similarities in their raw materials, but these tests were usually of too crude a character to make refined distinctions. Now, from the very fact that ancient potters were dependent on certain sources of supply for materials to produce certain wares, it was very natural that wares made by a certain people at a certain time were not made by that people at another period, or by different peoples. And such a case would probably be classified as a lost art. But this cannot properly be called a lost art. Rather it is a case of lost materials! Given the materials, the wares could be made as at first. This in fact has been the work of more recent times—to ascertain by careful analysis the nature of various bodies and glazes and reproduce them. Of course the composition is not the whole secret, the heat treatment is almost equally important, and this is a matter for careful physical testing. But as the result of modern research and practical experiment it can scarcely be maintained that any body or glaze exists which has not been and can not be reproduced.

Glass manufacture is allied to the ceramic industry, and is probably the outgrowth of it. In spite of Pliny's fable to account for the origin of glass making, it is altogether likely that glazes and enamels were the immediate forerunners of glass. Glass manufacture had its origin in Egypt, not far from 2500 B. C. Who shall say that the natural mineral resources of the country (among them limestone, sand and alkalis) were not responsible for its origin there? It spread to the countries east and north of Egypt, to Greece and Rome, to Spain, France, and more recently to Saxony, Bohemia and Austria—finally over the civilized world. At the present time the data for a history of glass manufacture are probably as complete and available as that for any other of the chemical industries—and possibly more so. The ancient glasses were usually not perfectly transparent, but were translucent, in some cases nearly opaque. Transparent glass, and particularly transparent glass in large sheets, is a modern production. Many of the ancient glasses and those of early modern times possessed great beauty, considered from the standpoint of the fine arts, although their utility as light transmitters is low. In Greece and Rome glass was used for plates and saucers and other table ware, for pitchers and ornamental objects, as tile in pavements and walls, but scarcely at all in windows. With the advent of transparent glass the production of the translucent varieties did not expand, until finally the art languished in many countries, and has but recently been revived for many decorative purposes. It should be noted that the art was never really lost, but the interest in and demand for translucent, tinted and rough-surfaced glass was low.

The dyeing industry is another which dates from the remotest antiquity, and which was developed without the aid of scientific chemistry, on an empirical groundwork. However, ancient colors, largely derived from vegetable sources, were reproducible. The use of mordants was practised by many ancient peoples, particularly by the ancient Egyptians, who used them not only for fixing colors, but for producing different shades from the same dye bath. With increasing commerce between nations, new sources of dyes became available, and the vegetable-dying practice had reached a high degree of perfection when the coal-tar dyes were brought forth in the chemical laboratory to the wonderment of mankind and the revolutionizing of the industry. It has never been claimed, I believe, that the art of dyeing with vegetable colors has been lost or not practised. But there is a strong tendency at the present time to disparage the aniline colors. It is very commonly said and accepted as true that vegetable dyes are superior to coal-tar dyes. That vegetable dyes are fast and coal-tar dyes are not. Persia has recently prohibited the exportation of rugs and fabrics dyed with anything but vegetable dyes, ostensibly to maintain her reputation in the rug industry. Who shall come forward and refute these charges, which are of course all but groundless? There are good and bad dyes, both coal-tar and vegetable, and the best dyes must be skilfully used to produce good results. Let us hope that the coal-tar dyes will be increasingly appreciated, and that the time will not come when people will lament the lost art of vegetable dying!

But what about the cement and plaster of the ancients which outlasted the ages and even the stones which it held together? In the first place, any cement or plaster which was not remarkably durable could not possibly have been preserved to this day. The ancients in various countries and at various times have been well acquainted with lime, burned clay-limestone (hydraulic lime), hydraulic cement, various natural cements, puzzolan, and plaster. Would it not be strange if, among the materials used, some would not be found to yield a cement of unusual strength? And if the setting process continued through the ages and conditions were such that weathering did not seriously attack it, the final product yielded would certainly be extremely hard. But in any case it is certain that the weaker cements have not come down to us, but have been disintegrated long ago. The cement which is being made in enormous quantity to-day under scientific control will probably outlast any similar material which the world has seen.

But we may go a step farther in our inquiry after relegating the "lost arts" to the same mythological museum which holds the lost Atlantis. Not only is it unlikely that there are any "lost" chemical arts, but it is highly probable that ancient peoples were ignorant of many arts attributed to them, and which are well known at the present day. Such a misunderstanding could probably best be dispelled by a carefully compiled history of arts and manufactures, particularly ancient arts and manufactures. The production of such a book is a consummation devoutly to be wished.

I have an idea that it is not a difficult matter to gain a mental picture of conditions in ancient workshops. I believe that the mental attitude of artisans has not changed much during the lapse of hundreds or even thousands of years. Go into any small shop at the present day where a specialized art or craft is practised, and I fancy that you will find the workers there, in all essential respects, so far as their craft is concerned, like the craftsmen of distant ages. You will find there the same lack of organized knowledge, the same sort of unnecessarily detailed and elaborated empirical knowledge, the same narrow conservatism and adherence to formulæ and rule-of-thumb methods. If you talk to the men you may learn how they learned their craft; of the most skilful members of the craft they have known; if you gain their confidence they may tell you of their past experiments (most of them foredoomed to failure) and of future experiments planned, when time permits or when they obtain material possessed of certain hypothetical properties. And you will be impressed by the way results are sometimes accomplished in spite of the use of the clumsiest mental and physical methods of experiment imaginable. A typical craftsman will experiment with all the materials he can lay hands on without the slightest scientific consideration of the case, in an effort to produce a certain result. These things are interesting and we must hope they will never be altogether lost. But our ideal for the present and the future must be a large and adequately organized industry, resting firmly on engineering skill and chemical investigation, operating with a full understanding of all its processes and with assurances of consistent and logical future development and expansion.—*Science.*

### The Atmosphere of Cities

THE German scientists are studying the atmospheric conditions of their cities. The fact that sunshine lessens as population becomes more dense, and especially when the activity of industrial centers expands superficially and increases in intensity, has long been noted. An increasing tendency to fog has also been observed, and both are effects of the imperfect and incomplete combustion of coal.

Modern industry pays toll for this in the injury of delicate fabrics, the general depreciation in the value of many articles of trade and household use, and the increased cost of cleansing. Since the battle is waged with growing energy against tuberculosis, physicians and students of social science feel that the problem of purer air for the dwellers in cities has become one of the first importance.

Statistics have been collected for some time past. They demonstrate that little sunshine falls to the lot of the residents of industrial cities even when the sun is obscured by smoke particles. In no German city has the loss of sunshine, due to fogs, equaled that of London, where the foggy days during the three months of December, January and February increased from 18 to 31 during the last half of the last century.

**To Wash and Clean Embroideries.**—Dissolve 30 parts of borax in 1,000 parts of river water at moderate heat. In washing embroideries, do not rub but press them, rinse with cold water, to which a handful of salt has been added, rinse for a few minutes in sharp wine vinegar and press between two other cloths.

# Automatically Drawn Curves

## Instruments that Represent Varying Conditions

By Albert A. Somerville

A PIECE of apparatus frequently called for in scientific work is one that will automatically record varying conditions and draw a curve representing the relation between the variables. Some such instruments are used, for example, in the weather service work. One of the variables there is nearly always *time*, so an accurate time-keeping piece is part of the apparatus, being used to move a sheet of cross-section paper at uniform speed, while at right angles to the motion of the paper a lever arm moves in accordance with the change in length of a metal rod which expands or contracts with changes in temperature. At the same time, by means of a stencil arrangement pressing on the paper, the lever draws a time-temperature curve from which may be read the temperature corresponding to any instant of time during the period over which the record extends.

A very similar method may be used to record barometric pressures from day to day. The instrument employed for this purpose is known as a barograph, and may be used also to record altitudes reached by a balloon or aeroplane, the barometric pressure decreasing with increase in altitude.

In electrical work there is a big field for recording instruments, and in a well-equipped station there are kept automatically-made records of voltage, current, and power consumed, and for certain times in the day the cost of electrical energy is less to the consumer than at other hours during which there is a big demand made on the power station.

In all of these cases named one of the factors is the time variable.

Just as interesting are other cases involving dynamical data, e. g., forces and their directions, and the motions due to those forces. In such cases curves may be drawn representing the direction of motion only, without respect to time change.

One of the most interesting simple cases is that of circular motion as affected by friction, and the curves shown in the accompanying illustration are representative of such a case. The problem presented is of a type which is considered in probably every book on general physics now being used in schools or colleges.

On the principles underlying circular motion depend the following phenomena: The tendency of a spinning top to remain upright, the bursting of a rapidly rotating wheel, the performance of a "loop-the-loop," the action of cream separators and centrifugal drying machines, the force of a "sling-shot," the necessity for the elevation of the outer rail on a curve in a railroad, the lag and lead of trade winds, and lastly, an amusement device now being extensively used in popular parks, whose action resembles in some features the phenomena presented by the trade winds. It consists of a smooth horizontal wheel rotated about a vertical axis at such a speed as to throw off any particle resting upon it. The wheel is ordinarily 20 or 30 feet in diameter, and the amusement takes the form of allowing youngsters to pile onto it while it is at rest and then rotating it, gradually increasing the speed until everyone has slid off into the surrounding gutter.

The curves shown in Figs. 1 and 2 are from a model of such a device. In one of the recently published text books there appears the problem: "Given a certain value for the friction force, at what speed is it necessary for the wheel to turn in order that a body may just slide off?" To this may be naturally added the question, "In what direction would the body slide?"

In order to clearly understand the problem it is necessary to review briefly certain principles known as Newton's laws, relating to bodies in motion or at rest. All we need to know is that if a body is in motion it has a tendency to move in a straight line, and if it is kept moving uniformly in a circle there must be a constant force pulling in toward the center of the circle, or else the body will fly off at a tangent to the circle, as is the case with mud or water flying off a revolving wheel, or as exemplified by the direction in which a stone travels when revolved in a circle by means of a string and suddenly released by the snapping of the string.

It is also useful for us to knew that the amount of this force toward the center necessary to keep a body moving in a circle with a uniform velocity is equal to the algebraic expressions $\frac{MV^2}{R}$, in which $M$ is the mass or amount of material in the body, $V$ its linear velocity, and $R$ the radius of the circle in which it is moving. From this we see that as the speed $V$ increases, the force necessary to hold the body in the circle increases, and also the smaller $R$ the radius of this circle, the smaller is this force.

In the case of the boy sitting on the rotating horizontal wheel the only force that holds him at the center or that keeps him from sliding out is friction between him and the surface of the wheel. Now friction is something which depends on the nature of the two surfaces in contact. The force necessary to overcome friction is equal to a certain constant $K$, characteristic of the surfaces in contact, multiplied by the pressure between those surfaces, or in this case by the weight of the body, which is equal to its mass $M$ multiplied by the acceleration of gravity $g$.

The friction $Mgk$ is constant. If the speed of the wheel is increased the body will begin to slide when $\frac{MV^2}{R}$ becomes equal to or just greater than $Mgk$, i. e., as soon as the equation $\frac{MV^2}{R} = Mgk$ is satisfied. Since $M$ occurs on both sides of the equation, we see that the motion is independent of the size or mass of the body, and since the force varies as $\frac{V^2}{R}$, and $V$ the linear speed varies directly as $R$, it is evident that a body near the edge will start to slide sooner than one near the center of the wheel. To draw the curves a model wheel 2 feet in diameter was used, mounted on a variable speed motor. The wheel was covered with a sheet of paper and a block holding a pencil placed on it. The wheel was then speeded up until the block carrying the pencil would slide off and trace its own path on the paper. The wheel was run in a counter clockwise direction, as indicated by the arrows on the central circle. The block starts to slide off along the radius of the wheel, but soon falls behind, as shown in the curves of Fig. 1. Traces of the paths are shown, starting near the center, and also starting about half-way out from the center. Curves 1, 2 and 3 represent different accelerations or rates of bringing the wheel up to speed. Curve 1 is the path of the moving block when the wheel is very slowly brought up to speed, and curve 3 when it is quickly brought to the speed at which sliding starts. In all these curves the motion is represented with respect to the wheel, which is itself in motion, and taking any radius of the wheel we see that with respect to this line a body sliding on the wheel continually slides backward. If, now, as in Fig. 2, the curves are drawn with respect to a fixed system, say the earth, instead of the wheel, which is moving, we get an entirely different set of curves, showing that when the body begins to slide it starts on a spiral, but while the motion of the body with respect to the wheel was backward, with respect to the earth it is forward. The curves in Fig. 2 were drawn by placing the block bearing the pencil on the wheel, but pointing the pencil upward and having it attached to a spring to make it press against the lower side of a sheet of paper fastened to a fixed plane above the pencil. Inasmuch as the curves of Fig. 2 are, as it were, inversions of those of Fig. 1, it is only necessary to reverse the motion of the wheel in order to obtain with the second arrangement tracings similar in character to those prepared by the first method.

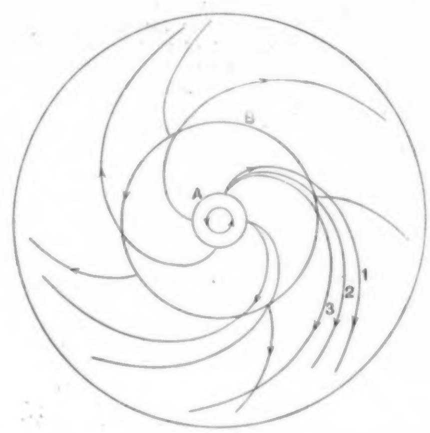



Fig. 1

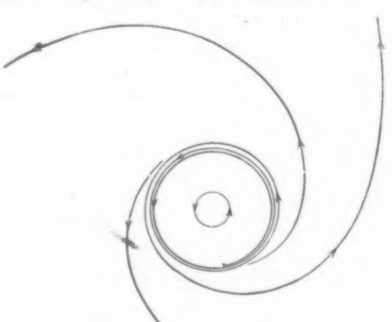
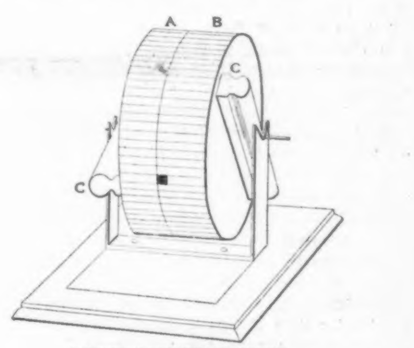


Fig. 2

CURVES TRACED BY POINT SLIDING OFF ROTATING HORIZONTAL DISK

### Multi-Cipher Device

JAMES TREVOR in the *Aust. Min. Stand.*, describes a multi-cipher device devised by him and shown in an accompanying illustration. This device consists of two cylinders mounted loosely on an axle, but so arranged that they can be securely clamped together in any position. The axle rests in standards on a base board. In the illustration, $A$ is the cylinder on which are the code words; $B$ the one on which is the key to the code. $C$ is a handle for aiding in turning the cylinders. In case one pair of cylinders is not enough other pairs of cylinders can be mounted on the same axle. A certain phrase in the key is always selected as the one opposite which the keyword of the code is to be clamped. Each message is prefaced by a key word so that for each message the code is changed. This prevents easy deciphering of the code used, and the message can be read more easily than if a book has to be used.




MULTI-CIPHER DEVICE.

## TABLE OF CONTENTS